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Hot Water Tie In and AHU Replacements

Texas Registered Engineering Firm # 2234
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<table>
<thead>
<tr>
<th>SECTION 00 01 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>TABLE OF CONTENTS</td>
</tr>
</tbody>
</table>

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205018

DBR ENGINEERING CONSULTANTS, INC.

02-25-2021

DIVISION 01 - GENERAL REQUIREMENTS

Section 01 74 19 - Construction Waste Management and Disposal
Section 01 91 00 - General Commissioning Requirements

DIVISION 23 - HEATING, VENTILATING, AND AIR-CONDITIONING (HVAC)

Section 23 02 00 - Basic Materials and Methods for HVAC
Section 23 02 01 - Coordination Drawings
Section 23 03 00 - Mechanical Demolition for Remodeling
Section 23 05 13 - Common Motor Requirements for HVAC Equipment
Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping
Section 23 05 26 - Variable Frequency Motor Speed Control for HVAC Equipment
Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
Section 23 05 53 - Identification for HVAC Piping and Equipment
Section 23 05 93 - Testing, Adjusting, And Balancing
Section 23 07 13 - Duct Insulation
Section 23 07 16 - HVAC Equipment Insulation
Section 23 07 19 - HVAC Piping Insulation
Section 23 08 00 - Commissioning of HVAC Systems
Section 23 09 63 - Energy Management and Control System (EMCS)
Section 23 21 13 - Above Ground Hydronic Piping
Section 23 21 16 - Underground Hydronic Piping
Section 23 21 19 - Hydronic Specialties
Section 23 21 23 - Hydronic Pumps
Section 23 31 13 - Metal Ductwork
Section 23 33 00 - Ductwork Accessories
Section 23 34 00 - HVAC Fans
Section 23 37 13 - Air Distribution Devices
Section 23 41 00 - Air Filters
Section 23 41 01 - Air Purification System
Section 23 73 13 - Modular Indoor Central Station Air Handling Units
Section 23 82 19 - Fan Coil Unit

DIVISION 26 - ELECTRICAL

Section 26 02 00 - Basic Materials and Methods for Electrical
Section 26 02 01 - Coordination Drawings
Section 26 03 00 - Demolition Work
Section 26 03 13 - Electrical Demolition for Remodeling
Section 26 05 19 - Wire, Cable and Related Materials
Section 26 05 26 - Grounding
Section 26 05 33 - Raceways
Section 26 05 73 - Short Circuit Coordination Study Arc Flash Hazard Analysis
Section 26 06 34 - Low Voltage Raceway System
Section 26 08 00 - Commissioning of Electrical Systems
Section 26 22 13 - Low Voltage Distributions Transformers
Section 26 24 16 - Panelboards
Section 26 27 26 - Wiring Devices
Section 26 28 13 - Fuses
Section 26 28 16 - Safety and Disconnect Switches
Section 26 29 26 - Miscellaneous Electrical Controls and Wiring
Section 26 43 13.13 - Surge Protective Devices (SPD) - Standard Interrupting

END OF SECTION
SECTION 01 74 19
CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

PART 1 - GENERAL

1.01 SUMMARY

A. Section includes requirements for waste reduction and for the recycling of non-hazardous, recyclable, construction and demolition debris.
   1. Reduce waste by minimizing factors that contribute to waste.
   2. Use reasonable and legal means to divert construction and demolition debris from landfills and incinerators by facilitating their recycling or reuse through a Contractor developed, and Owner reviewed, construction waste management program.

1.02 DEFINITIONS

A. Waste Reduction: Construction practices that achieve the most efficient use of resources and materials; uses water efficiently; avoids practices such as over-packaging, improper storage, ordering errors, poor planning, breakage, mishandling and contamination.

B. Construction and Demolition Debris: Solid wastes arising from demolition or removal, excess or unusable construction materials, packing materials for construction products, and other materials generated on site during the construction process but not incorporated into the Work.

C. Recyclable Materials: Construction and demolition debris that can be recovered and processed into new products or materials. Recyclable materials include, but are not limited to, the following:
   1. Metals: Ferrous (iron, steel, stainless steel, galvanized steel) and non-ferrous (copper, brass, bronze, aluminum) types and containers made from metals such as pails, buckets and beverage cans.
   2. Asphaltic concrete paving.
   3. Concrete.
   4. Gypsum wallboard.
   5. Paper products such as generated from field office activities and clean corrugated packing cardboard.
   6. Wood products, including untreated dimensional lumber, plywood, oriented strand board, hardboard, particleboard and crates and pallets made from wood products.
   7. Brick and stone masonry.
   8. Carpet and padding.
   9. Plastics and containers made from plastics such as pails, buckets, and beverage bottles.
   10. Copper wiring.
   11. Glass: Glass beverage containers, window and mirror glass.
   12. Clean and uncontaminated, excavated soils not intended for other on-site use.
   13. Stumps and trees removed as a part of land clearing operations.

D. Non-Recyclable Materials: Construction and demolition debris not capable of being reused or reprocessed, exclusive of the recyclable materials listed above.

E. Hazardous Materials: Construction and demolition debris that are regulated for disposal by local, city, county, state, or Federal authorities.

1.03 SUBMITTALS

A. Construction Waste Management Program: Submit the proposed waste management program appended to the bid. The program shall include the following:
   1. Identification of Contractor’s staff responsible for enforcing construction waste management.
   2. Actions that will be taken to reduce solid waste generation.
   3. Description of the specific methods to be used in recycling/reuse of the various construction and demolition debris generated, including the areas and equipment, to be used for processing, sorting, and temporary storage of debris.
   4. Characterization, including estimated types and quantities of the construction and demolition debris to be generated. Include percentages of recyclable and non-
recyclable debris.
5. List of specific construction and demolition debris materials that will be salvaged for resale, salvaged and reused, or recycled.
6. Name(s) of landfill and incinerator to be used and the estimated costs for use, for construction and demolition debris that is unable to be recycled or reused.
7. Identification of local or regional reuse programs, including non-profit organizations such as schools, local housing agencies, and organizations that accept used and excess construction materials such as materials exchange networks and Habitat for Humanity.
8. Identification of local recycling facilities that will accept construction and demolition debris.
9. Identification of construction and demolition debris that cannot be recycled/reused with an explanation or justification.
10. Anticipated net cost saving determined by subtracting Contractor program management costs and the cost of disposal from the revenue generated by sale of the construction and demolition debris and avoided landfill and incineration costs.

B. Waste Management Reports: With each Application for Payment submit a Waste Management Report in a form acceptable to the Architect and Owner. Attach manifests, weight tickets, receipts and invoices. Organize and maintain records to document the following:
1. Quantity of debris generated, for each material recycled, reused or salvaged.
2. Quantity of debris diverted through sale, reuse, or recycling, in tons or cubic yards.
3. Quantity of debris disposed by landfill or incineration.
4. Name and location of each firm accepting the debris, including:
   a. Types of debris accepted.
   b. Net weights of each type.
   c. Date of acceptance.
5. Transportation cost for removal of debris from job site.
6. Amount of money paid or received for the recycled, reused or salvaged materials.
7. Net total cost or savings of recycling, reusing or salvaging materials.

C. Project Closeout: Upon project completion submit the Waste Management Records to the Owner.

1.04 QUALITY ASSURANCE

A. Construction Waste Management: Prior to bid, prepare a program that minimizes waste and diverts construction and demolition debris from landfills and incinerators by facilitating their reuse or recycling. Name the waste materials processors who will accept the construction and demolition debris, the condition of the construction and demolition debris required by the waste material processors, the method proposed to provide the construction and demolition debris in suitable condition and quantity acceptable to the disposal sites and waste material processors whom will receive them, and the impact on the project schedule. The Contractor shall be responsible for implementation of any special programs involving rebates or similar reuse incentives related to the recycling of wastes. Revenues or other savings obtained from sale, reuse, and recycling operations shall accrue to the Contractor.

B. Disposal Sites and Waste Material Processors: Use only facilities with valid legal permits for disposal, recycling and waste processing issued by the jurisdictions in which they are located.

C. Pre-Construction Waste Management Meeting: Prior to beginning site preparation, schedule and conduct a meeting to review the waste management program. The meeting shall include the Contractor, the Architect, the Owner and any of the Contractor’s subcontractors or suppliers whose work will interface with the program. The agenda shall include a discussion of procedures, schedules and specific requirements for construction and demolition debris, sale, reuse, recycling, and disposal. Make any revisions to the program that are agreed to as a part of the meeting and submit the revised program and meeting minutes to the Architect and Owner for their records.
PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 WASTE MANAGEMENT PLAN IMPLEMENTATION

A. Distribution: The Contractor shall distribute copies of the Waste Management Plan to the Job Site Foreman, each Subcontractor, the Owner and the Architect.

B. General: For the duration of the project implement and maintain construction waste management. During the prosecution of the Work encourage the practice of efficient waste reduction when sizing, cutting, and installing products and materials.

C. Transportation: Arrange for the regular collection, transport from the site, and delivery of the construction wastes and debris to the designated recyclers, and waste material processors and disposal sites.

D. Separation Facilities: The Contractor shall provide on-site instruction of appropriate separation, handling separation, handling, and recycling, salvage, reuse and return methods to be used by all parties at the appropriate stages of the Project. Provide and designate an on-site area for the separation of construction and demolition debris for reuse and recycling. Locate the area in order that non-recyclable debris will not contaminate materials to be reused or recycled. Provide containers and bins in the designated area to facilitate separation, storage and handling which are clearly and appropriately marked. Cut all items to lengths and sizes to fit within the containers or bins provided. Where there is sufficient quantity of a specific recyclable debris item (for example; salvaged metal doors and frames or duct work), make arrangements for items to bundled, banded or tied, and stacked in a designated location for a special pick-up. Maintain the separation facilities in an orderly condition to prevent contamination of materials placed therein and to maximize reuse and recyclability of debris. Separate construction and demolition debris at the project site by one of the following methods:

1. Source Separated Method: Construction and demolition debris, that is reusable and recyclable, are separated from non-recyclable debris and sorted into appropriately marked separated containers or bins and then transported to the designated recycling facility for further processing. Non-recyclable debris is transported to a landfill or incinerator.

2. Co-Mingled Method: All construction and demolition debris is placed into containers or bins and then transported to a recycling facility where recyclable and salvageable materials are removed, sorted, and processed and the remaining waste is transported to a landfill or incinerator.

END OF SECTION
SECTION 01 91 00

GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. This section includes general requirements that apply to implementation of the commissioning process without regard to systems, subsystems, and equipment being commissioned.

B. Commissioning is a systematic process to provide documented confirmation the building systems perform according to the criteria set forth in the design documents and satisfy the Owner's Project Requirements and the facility's operational needs.

C. Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:
   1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
   2. Verify and document proper performance of equipment and systems.
   3. Verify that O&M documentation provided to the Owner and is complete.
   4. Verify that the Owner's operating personnel are adequately trained.

D. The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.
   1. Related Sections include, but not limited to the following:
      a. Section 22 08 00 - Commissioning of Plumbing Systems
      b. Section 23 08 00 - Commissioning of HVAC Systems
      c. Section 23 09 03 - Energy Management and Control System (EMCS)
      d. Section 26 08 00 - Commissioning of Electrical Systems

E. Owner's Project Requirements (OPR) and Basis of Design (BOD) documentation are included by reference for information only.

F. The specified commissioning process shall be performed by an impartial technical firm hired by the owner. The commissioning firm shall be certified under one or more of the following certifications:

G. CxA - Certified Commissioning Authority - ACG
H. CBCP - Certified Building Commissioning Professional - AEE
I. CCP - Certified Commissioning Professional - BCA
J. CPMP - Certified Process Management Professional - ASHRAE
K. BSC - Building System Commissioning Certification - NEBB

L. The commissioning firm (Commissioning authority) shall be responsible for leading the entire construction team through the commissioning process including, but not limited to, conducting the commissioning kick-off meeting, preparing the commissioning plan, preparing pre-functional checklists, preparing functional test scripts, participation in functional testing and preparation of required documentation and reports.

1.02 DEFINITIONS

A. Approval: Acceptance that a piece of equipment or system has been properly installed and is functioning in tested modes according to Contract Documents.

B. Basis of Design: Documentation of primary thought processes and assumptions behind design decisions that were made to meet design intent and satisfy applicable regulatory requirements, standards, and guidelines. Describes systems, components, conditions, and methods chosen to meet intent. The document includes both narrative descriptions and lists of individual items that support the design process.

C. Building Commissioning: A joint team effort to ensure that all mechanical equipment, controls, and systems function together properly to meet the design intent, to document system performance parameters and to ensure that personnel are adequately trained to
operate systems.

D. Commissioning Authority: The independent commissioning provider, hired by the owner that will oversee the entire commissioning process.

E. Commissioning Process (Cx): A process which coordinates the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, training and performance testing. Commissioning requirements do not supersede other requirements of the specifications, but may expand on some of them.

F. Commissioning Agent (CxA): Independent agent hired by Owner. Under Owner’s direction, and not Contractor’s direction, CA will direct and coordinate day-to-day commissioning activities without assuming oversight responsibilities.

G. Commissioning Team: Consists of Commissioning Agent, the Owner or Owner's Representative, Design Team, Contractors, Subcontractors, and Vendors.

H. Owner’s Project Requirements (OPR): A document that details the functional requirements of a project and the expectations of how it will be used and operated. These include Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information.

I. Functional Performance Test (FPT): Test of the function of systems, as opposed to components, under full operation in various modes through all control system’s sequences of operation using manual (direct observation) or monitoring methods following prescribed test procedures in sequential written form.

J. Pre-Functional Checklist (PFC): Checklist provided by Commissioning Agent, of items to inspect and elementary component tests to conduct to verify proper installation of equipment prior to functional testing.

K. Sampling: Functionally testing only a fraction of total number of identical or near identical pieces of equipment.

L. Seasonal Testing: Testing of equipment which can be done only during periods of peak heating or cooling, when HVAC equipment is operating at full-load or heavy-load conditions.

M. Simulated Condition: Condition created for purpose of testing response of system.

N. Trending: System monitoring using the Building Automation System.

1.03 RESPONSIBILITIES

A. The Commissioning Agent: Responsibilities of the CxA include, but are not limited to the following:

1. Coordinate and direct each step of the Commissioning Process for systems being commissioned for this project. Coordinate commissioning work schedule with Project Manager and Contractor.

2. Attend planning and job-site meetings as required to obtain information relating to Commissioning Process.

3. Plan and conduct commissioning scoping and coordination meetings. Provide notice to all Team members to attend scheduled commissioning meetings.

4. Ensure all information required for Commissioning Process from manufacturers, Contractors, and A/E design team is available.

5. Review A/E design documents to gain clear understanding of design intent.

6. Review Contractor submittals for compliance with commissioning needs.

7. Verify that systems and equipment have been installed and started in accordance with manufacturer’s recommendations and with generally recognized construction standards and that documentation of such has been provided.

8. Prepare Pre-Functional Checklists to ensure systems have been installed according to project specifications. Verify that Pre-Functional Checklists have been completed by Contractor and are accurate.

9. Prepare Functional Testing procedures to demonstrate performance of systems according to project specifications. Observe and document performance of systems, as per process detailed in Functional Test procedures.


11. Recommend acceptance or non-acceptance of systems to Owner.
12. Verify that Operations and Maintenance (O&M) documentation is acceptable. Operations and Maintenance manuals shall be submitted simultaneously to CxA and to Design Professionals for review.
13. Verify that Owner training is completed for all systems to be commissioned.
14. Compile and maintain commissioning record.
15. Provide final Commissioning Report to Owner.
16. Prepare and maintain commissioning “Issues Log”.

B. Contractor: Responsibilities of the Contractor as relate to Commissioning Process include, but are not limited to the following:
   1. Facilitate coordination of commissioning work by CxA.
   2. Attend Commissioning meetings or other meetings called by CxA to facilitate the Commissioning Process.
   3. Review Functional Testing procedures for feasibility, safety, and impact on warranty, and provide CxA with written comment on same.
   4. Provide all documentation relating to manufacturer’s recommended performance testing of equipment and systems.
   5. Provide Operations and Maintenance Data to CxA for preparation of checklists and training manuals.
   6. Provide testing and balancing report.
   7. Assure and facilitate participation and cooperation of subcontractors (electrical, mechanical, controls, etc.) and equipment suppliers as required for the Commissioning Process.
   8. Certify to CxA that installation work listed in Pre-functional Checklists has been completed.
   9. Install systems and equipment in strict conformance with project specifications, manufacturer’s recommended installation procedures, and Pre-Functional Checklists, as prepared by CxA.
  10. Provide data concerning performance, installation, and start-up of systems.
  11. Provide copy of manufacturer’s filled-out start-up forms for equipment and systems.
  12. Ensure systems have been started and fully checked for proper operation prior to arranging for Functional Testing with CxA. Prepare and submit to CxA written certification that each piece of equipment and/or system has been started according to manufacturer’s recommended procedure, and that system has been tested for compliance with operational requirements.
    a. Contractor shall carry out manufacturer’s recommended start-up and testing procedures, regardless of whether or not they are specifically listed in Functional Test procedures.
    b. Contractor is not relieved of obligation for systems/equipment demonstration where performance testing is required by specifications, but a Functional Performance Test is not specifically designated by CxA.
  13. Coordinate with CxA to determine mutually acceptable date of Functional Performance Tests.
  14. Provide test instruments and communications devices, as prescribed by CxA, required for carrying out Functional Testing of systems.
  15. Ensure deficiencies found in the Commissioning Process are corrected within the time schedule shown in the CA report.
  16. Provide CxA with all submittals, start-up instructions manuals, operating parameters, and other pertinent information related to Commissioning Process. This information shall be routed through Architect.
  17. Prepare and submit to CxA proposed Training Program outline for each system.
  18. Coordinate and provide training of Owner’s personnel.
  19. Prepare Operation and Maintenance manuals and As-Built drawings in accordance with specifications; submit copy to CxA in addition to other contractually required submissions. Revise and resubmit manuals in accordance with A/E and CxAs comments.
  20. All costs associated with the participation of Contractor, Sub-Contractors, Design Professionals, and Equipment Vendors in the Commissioning Process shall be included in the scope of this contract.
  21. Provide written response to resolution of items listed in “Issue Log”.

General Commissioning Requirements

01 91 00 - 3
C. Subcontractors and vendors shall prepare and submit to Commissioning Agent proposed Pre-Functional and Functional Performance Test procedures to demonstrate performance of systems according to these specifications and checklists prepared by Commissioning Agent.

D. Owner’s Representative: Responsibilities of the Owner’s Representative as related to Commissioning Process include, but are not limited to the following:
   1. Manage contracts of Architect and Contractor.
   2. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions.
   3. Provide final approval for completion of commissioning Work.
   4. Warranty Period: Ensure that seasonal or deferred testing and deficiency issues are addressed.

E. Architect: Responsibilities of the Architect as related to the Commissioning Process shall include, but are not limited to the following:
   1. Attend commissioning scoping meeting and other commissioning team meetings as requested by Commissioning Agent and as selected by Architect.
   2. Perform normal submittal review, construction observation, record drawing preparation, and operations and maintenance data preparation, as required by Contract Documents.
   3. Provide design narrative documentation requested by Commissioning Agent.
   4. Coordinate resolution of system deficiencies identified during commissioning, as required by Contract Documents.
   5. Prepare and submit final as-built design intent documentation for inclusion in Operation and Maintenance Data Manual, and review and approve Operation and Maintenance Data Manual.
   6. Warranty Period: Coordinate resolution of design non-conformance and design deficiencies identified during warranty period commissioning.

F. Mechanical, Electrical, and Plumbing Engineers: Responsibilities of the Engineers as related to the Commissioning Process shall include, but are not limited to the following:
   1. Perform normal submittal review, construction observations, and record drawing preparation, as required by Contract Documents. Perform site observation immediately preceding system startup.
   2. Provide design narrative and sequence documentation requested by Commissioning Agent. Assist, along with Contractor, in clarifying operation and control of commissioned equipment in areas where specifications, control drawings, or equipment documentation are not sufficient for writing detailed testing procedures.
   3. Attend commissioning scoping meetings and other commissioning team meetings as requested by Commissioning Agent and as selected by Architect or responsible design professional.
   4. Participate in resolution of system deficiencies identified during commissioning, as required by Contract Documents.
   5. Prepare and submit final as-built design intent and operating parameters documentation for inclusion in Operation and Maintenance Manual, and review and approve Operation and Maintenance Manual.

1.04 COMMISSIONING PLAN

A. Commissioning Process tasks and activities:
   1. Commissioning kick-off meeting: Conducted by commissioning authority and attended by construction team and design team.
   2. Pre-functional checklists: Prepared by the commissioning authority and filled out by subcontractors performing the work that is applicable.
   3. Site visits to review installation of applicable systems and progress of checklist documentation performed and reported by commissioning authority.
   4. Functional testing: Commissioning authority shall conduct functional testing with assistance of applicable subcontractors and document successful results as well as deficiencies (issues). Functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing in accordance with plans and specifications. Testing shall include all modes and sequence of operation, including under full-load, part-load and emergency conditions.
(including all alarms). Controls system shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in accordance with the plans and specifications. Sequences shall be functionally tested to document they operate in accordance with plans and specifications.

5. Preliminary commissioning report: Commissioning authority shall issue a preliminary commissioning report to the owner that has results of the first round of functional testing including deficiencies discovered.

6. Air and hydronic system balancing: Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the contract documents. System balancing shall be performed by T.A.B. contractor as specified in 23 05 93 - Testing, Adjusting, And Balancing.

7. Systems manual: Commissioning authority shall compile the systems manual using submittal data provided by the general contractor and applicable subcontractors.

8. Final commissioning report: Commissioning authority shall issue final commissioning report documenting the entire process and final results of functional testing. Report shall include final testing and balancing report.

B. Mechanical System equipment to be tested
   1. Energy Management and Control System:
      a. Graphical User Interface
      b. Automation Software
      c. Field Level Controllers
      d. Field Level Devices
      e. Control Sequences
   2. Chilled Water Systems (All chillers and pumps)
   3. Condenser Water Systems (All towers and pumps)
   4. Heating Water Systems (All boilers and pumps)
   5. Air Handling Systems (All AHU and 10% of terminal units)
   6. Energy Recovery Systems (100%)
   7. Water Treatment Systems (Verify vendors completion of scope)
   8. Service water heating systems (100%)
   9. Service water heating circulation systems (100%).
   10. Domestic water booster pumps (100%).

C. Electrical System Equipment to be tested
   1. Occupancy sensors.
   2. Time switch controls
   3. Daylighting controls.

D. Testing functions and conditions
   1. Energy conservation programs (economizer, optimal start, etc)
   2. Verify shutdown of systems when scheduled.
   3. Calibration of sensors
   4. Testing shall affirm winter and summer design conditions.
   5. Test under full outside air conditions.
   6. Confirm functionality of all specified sequences of operations.
   7. Verify the functionality of all alarms.
   8. Verify daylititing control devices have been calibrated, properly located, adjusted and respond as specified.
   9. Verify time switch schedule, time, date and programming is accurate. Verify override time limit is set, battery is installed and switch operates the lights that are specified in the design documents.
   10. Verify that occupant sensor has been located and aimed in accordance with manufacturer instructions. Testing shall be done for each unique combination of sensor type and space geometry.

E. Performance criteria
   1. Air and water temperatures shall be within tolerances specified in the contract documents.
   2. Space temperatures shall be maintained within 1 degree of specified set points.
   3. Space humidity shall be maintained within 5% of specified levels.
4. Heating water recovery shall be within specified time frame and temperature.
5. Daylighting controls shall maintain specified light levels within 5% of design.
6. All time switches shall be accurate to time on cellular network devices.

PART 2 - PRODUCTS (NOT USED)
PART 3 - EXECUTION
3.01 GENERAL
A. Contractor shall coordinate with sub-Contractors and equipment vendors/representatives to set aside adequate time to address Pre-Functional Testing, Functional Testing, Operations and Maintenance Training, and associated coordination meetings.
B. CxA may also conduct site inspections at critical times and issue Cx Field Reports with observations on installation deficiencies so that they may be issued by Architect as deemed appropriate.

3.02 MEETINGS
A. A commissioning team scoping meeting shall be held at a time and place agreed upon shortly after the beginning of the construction phase of the project. Owner, Commissioning Agent, General Contractor, Architect, Mechanical Subcontractor, and Electrical Subcontractor shall be present at this meeting. The purpose of the meeting is to familiarize all parties with the requirements of the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
B. Separate meetings including individual equipment suppliers and subcontractors shall be held prior to commissioning of their systems at the discretion of CxA.
C. Miscellaneous Meetings. The CxA shall plan and conduct other meetings as required as construction progresses. Meetings will cover coordination, deficiency resolution, and planning issues with particular subcontractors. CxA will plan meetings to minimize unnecessary time being spent by subcontractors.

3.03 PRE-FUNCTIONAL CHECKLISTS (PFC)
A. General
1. Pre-functional checklists are important to ensure that equipment and systems are properly connected and operational, and installed in accordance with specifications, drawings, manufacturer's requirements, and all applicable codes.
2. Checklists ensure that functional performance testing (in-depth checkout) may proceed without unnecessary delays.
3. Performance of pre-functional checklists, startup, and checkout shall be directed and executed by subcontractor or vendor. Only individuals that have direct knowledge and who witnessed that line item task on pre-functional checklist was performed shall initial or check item off.
4. Each piece of equipment receives full pre-functional checkout. No sampling strategies are used.
5. Pre-functional checkout for given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of given system.
B. Pre-Functional Checklist
1. Pre-functional performance tests shall be documented in a checklist format, as prepared and provided by CxA, for each piece of equipment. Each checklist shall be initialed by Contractor.
2. Commissioning Pre-functional checklists are not to preclude Contractor from applying his own construction inspection checklists.
3. All system elements shall be checked to verify that they have been installed, adjusted, and calibrated properly, that all connections have been made correctly, and that it is ready to function as specified. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, control sequence, and other conditions which may cause damage.
4. Verify that tests, meter readings and specific electrical characteristics agree with those required by equipment or system manufacturer.
5. All discrete elements and sub-systems shall be adjusted and shall be checked for proper operation. Verify wiring and support components for equipment are complete and tested.
6. Conduct start-up procedure recommended by equipment/system manufacturer.
7. Subcontractors shall clearly list outstanding items of initial start-up and pre-functional procedures that were not completed successfully at bottom of procedures form or on separate sheet attached to form. Completed form and attached sheets shall be provided to Commissioning Agent within 2 days of test completion. Installing subcontractor or vendor shall correct deficient or incomplete areas in timely manner and shall submit updated pre-functional checklist and startup report with statement of correction on original non-compliance report.

3.04 SYSTEM START-UP
A. Contractor will arrange for start-up of operating equipment and systems prior to scheduling Functional Testing.
B. Start-up of equipment and systems shall be performed only by a manufacturer’s representative, or person(s) who are specifically manufacturer-approved. All start-up personnel shall be trained and authorized, experienced and knowledgeable in the operations of such equipment and systems.
C. Coordinate schedule for start-up of various equipment and systems so that subsystems required for major systems operation are tested first.
D. Manufacturer’s start-up reports must be submitted to CxA prior to scheduling Functional Testing.

3.05 FUNCTIONAL PERFORMANCE TESTING
A. General
1. The objective of Functional Testing is to demonstrate that each system is operating according to documented design intent and Contract Documents, through all possible modes of operation.
2. Contractor and sub-Contractors shall include in his bid proposal all costs associated with preparation and execution of Testing Procedures.
3. Functional Testing is intended to begin upon completion of each system. Functional Testing may proceed prior to completion of systems or sub-systems at discretion of Commissioning Agent and Construction Administrator. Beginning system testing before completion, does not relieve Contractor from fully completing system, including pre-functional checklists as early as possible.
4. Contractor and sub-Contractors shall provide detailed Testing Procedures that will allow all items on checklists to be verified.
5. Testing shall be conducted under specified operating conditions as recommended or approved by Commissioning Agent.
6. A Functional Performance Test shall be performed on each complete system. Each function shall be demonstrated to the satisfaction of Commissioning Agent in accordance with proposed test procedures developed to demonstrate compliance with specifications.
7. Each Functional Test shall be witnessed and signed off by Owner and Commissioning Agent upon satisfactory completion.
8. All elements of system shall be tested to demonstrate that total systems satisfy all requirements of these specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each subsystem, followed by the entire system, followed by any inter-ties to other major systems.
9. All major testing materials and equipment shall be provided by contractor.
B. Notification, Scheduling Of Functional Testing and Re-Testing
1. Notify CxA and Owner, in writing, of request for scheduling Functional Testing. Submit request no fewer than five business days prior to desired day of testing.
   a. Contractor must certify that systems and equipment are functioning satisfactorily, according to specifications and design intent, prior to requesting Functional Testing. Upon receipt of such certification, CxA will schedule with Contractor a time for the particular system test.
   b. CxA will attempt to schedule Functional Testing when convenient for Contractor and his vendors, and to minimize lost time to Contractor.
   c. Contractor will resolve all deficiencies identified during initial test prior to submitting request, in writing, for re-testing. Such request for re-testing shall
certify that Contractor has resolved all deficiencies, or list reason why any deficiencies remain which cannot be resolved.
d. CxA will re-test to ensure that all deficiencies have been resolved.
e. Deficiencies that were not detected in first Functional Test, but are discovered in subsequent re-testing, are to be resolved by Contractor as if they had been discovered in initial testing.

C. Functional Testing Requirements And Procedures
1. Contractor and Subcontractors shall perform tests in the presence of CxA. Tests not witnessed by CxA shall not be considered complete.
2. To facilitate Functional Testing, when requested by CxA, Contractor shall provide services of personnel to accompany CxA for the duration of Functional Testing, including any follow-up testing. Such personnel must be experienced, qualified, and intimately familiar with the system being tested.
   a. Participation by representative(s) of the Building Automation Contractor is of particular importance in Functional Testing. All systems which are controlled and / or monitored by BAS are to be thoroughly tested, point by point, through all modes of operation, with the assistance of the Contractor’s representative. Graphics, setpoints, and programming are to be included as a part of Functional Testing as well.
   b. Contractors must provide services of personnel to accompany CxA for equipment and systems which may pose particular health and safety concerns, such as boilers.
   c. Should he fail to provide representative to accompany CxA during Functional Testing, Contractor continues to bear full responsibility for equipment warranty. Owner and CxA will not be held responsible for damage to equipment, or other actions which might impact warranty, when performing Functional Testing of systems where Contractor has not provided authorized accompanying representative to operate equipment.
3. Each system shall be operated through all modes of operation including, but not limited to seasonal, occupied, unoccupied, warm-up, cool-down, part-load, and full-load, where system response is specified.
   a. For multiple units, sampling strategy established by Commissioning Agent and subject to approval of Construction Administrator may be used.
   b. Verification of each sequence in sequences of operation is required.
   c. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, and the like, shall also be tested.
4. Functional Testing is to be dedicated solely to testing of equipment and systems, and not to resolution of deficiencies. Deficiencies identified during testing process must be corrected by Contractor at a time other than during Functional Testing.
5. CxA shall issue test reports with readings and checklists and a listing of any deficiencies that must be addressed by Contractor or sub-Contractors.
6. Commissioning Agent shall submit a Final Report to Owner recommending acceptance or non-acceptance of individual system components as well as the systems as a whole.
7. DBR has included a small contingency for limited retesting, however DBR reserves the right to stop testing on a system when the system:
   a. Does not have the correct graphics programmed.
   b. Does not have the correct data trends programmed.
   c. Does not have the correct set points programmed.
   d. Does not have the equipment or system safeties installed and programmed correctly.
   e. The TAB data forms have not been submitted to our firm or the performance of the system listed on the TAB forms is not per project requirements.
   f. Line items of the functional performance test have failed.
8. Sampling
   a. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy.
   b. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A
small size or capacity difference, alone, does not constitute a difference. It is noted that no sampling by Subs is allowed in prefunctional checklist execution.

c. A common sampling strategy is the “xx% Sampling - yy% Failure Rule”, defined by the following example.
1) \( xx = \) the percent of the group of identical equipment to be included in each sample.
2) \( yy = \) the percent of the sample that if failing, will require another sample to be tested.
3) The example below describes a 20% Sampling - 10% Failure Rule.
   a) Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the “first sample.”
   b) If 10% (yy) of the units in the first sample fail the functional tests, test another 20% of the group (the second sample).
   c) If 10% of the units in the second sample fail, test all remaining units in the whole group.
   d) If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.
4) If a second sampling and a whole group round of testing is required, the commissioning agent will charge the contractor an hourly rate of $150.00 for time and expenses associated with the testing.

D. Re-Testing And Failure To Remedy Deficiencies
1. Despite Contractor’s best efforts to ensure systems are problem-free, it is expected that some deficiencies will be found during initial inspection of Pre-functional Checklist, and during initial Functional Testing; such deficiencies are expected to be minimal.
2. It is Contractor’s responsibility to remedy identified deficiencies, both in Pre-functional Checklist and in Functional Testing phases of work, in a timely and thorough manner.
3. It is Contractor’s responsibility to ensure that all deficiencies are corrected prior to requesting a re-inspection or re-test of systems and equipment. Do not request re-inspection or re-test until deficiencies are corrected.
   a. At his discretion, CxA may agree to re-testing systems or equipment where deficiencies remain which are beyond Contractor’s control to resolve expeditiously.
   b. Typically such re-testing of incomplete systems and equipment will take place only if remaining deficiencies are minor in scope and nature, and are of such nature that they cannot be resolved in a timely manner (such as those due to difficulties in obtaining parts, or where Owner has requested a change that has delayed work, etc.)
4. CxA will carry out a second re-inspection or re-test of systems and equipment subsequent to receiving Contractor’s request.
   a. If CxA finds deficiencies identified in initial inspection or test have not been remedied (with exception of un-resolvable deficiencies in 3.b. above), and such remaining deficiencies are significant enough to require additional inspection or re-testing, Contractor will be back-charged for CxA’s expenses, and time at a rate of $150.00 per hour and $100.00 expenses, for a third and any subsequent re-inspections and re-tests.

E. Deferred Testing
1. Seasonal Commissioning” pertains to testing during peak heating or cooling seasons when HVAC equipment is operating at full-load or heavy-load conditions. Initial commissioning will be done as soon as contract work is completed, regardless of season. Seasonal Commissioning under full- or heavy-load conditions other than the current season will be handled at later time by GC and CxA.
2. If adequate load may be artificially placed upon heating or cooling equipment, CxA, at his discretion, may perform functional testing during non-peak load periods.
3. GC is to provide services of personnel and participate in seasonal testing process in the same manner as he would in non-seasonal testing.
4. Until off-season commissioning can be accomplished, Owner may retain an amount from GC's payment sufficient to cover the cost of off-season testing.

5. Unforeseen Deferred Tests: If any check or test cannot be completed due to building structure, required occupancy condition, or other reason, execution of checklists and functional testing may be delayed upon approval of Owner. Tests shall be conducted in same manner as seasonal tests, as soon as possible. Services of required parties will be negotiated. Make final adjustments to Operation and Maintenance Manuals and record drawings due to unforeseen deferred tests.

6. GC is to provide services of personnel and participate in deferred testing in the same manner as he would for normal commissioning.

7. Until deferred testing can be accomplished, Owner may retain an amount from GC's payment sufficient to cover the cost of deferred testing.

### 3.06 TRAINING

**A. Scheduling**

1. Provide a proposed schedule and outline of training of Owner's personnel for Commissioning Agent's review approximately 30 days before project completion. The Commissioning Agent will review the submittal.

2. Submit revised outline and fully developed training materials for review by Commissioning Agent, 10 business days prior to scheduled training sessions.

3. Organize training to fit Owner's schedule and to optimize the learning experience. Limit continuous sessions to no more than three hours at a time, or otherwise only as approved by Owner and/or Architect/Engineer.

**B. Training Materials**

1. Develop Training Manuals to meet requirements of individual equipment specification sections.

2. Operating and Maintenance Manuals alone are NOT considered training manuals. O&M Manuals may be used as reference, but shall not be considered to meet requirements for training materials.

3. Develop a detailed outline showing how training program will be organized, including classroom and hands-on training as required by individual specifications sections.

4. Provide with training materials, a quick-reference "how-to" index which will allow operators to easily access information included in Training Manuals and/or O&M Manuals. This reference will include, as a minimum; routine normal operating instructions and sequences. Include regulation, control, stopping, shut-down, and emergency instructions.

5. Refer to individual equipment or system specifications for minimum material to be covered as part of the training program.

**C. Training session agenda**

1. The training agenda (plan) shall include, at a minimum, the following elements:
   2. Purpose of equipment.
   3. Principle of how the equipment works.
   4. Important parts and assemblies.
   5. How the equipment achieves its purpose and necessary operating conditions.
   6. Most likely failure modes, causes and corrections.
   7. On site demonstration.

### 3.07 DOCUMENTATION

**A. Commissioning authority shall provide documentation of process as follows:**

1. Preliminary commissioning report including test procedures, results of testing, itemization of deficiencies, deferred tests and climatic conditions required for performance of deferred tests. Preliminary commissioning report shall be issued to owner to demonstrate the first pass of testing has occurred and to demonstrate compliance with applicable codes.

2. Final commissioning report shall include the final test and balance report, final results of functional testing, disposition of deficiencies discovered during testing, including the details of corrective measures used and functional testing procedures used for repeatability of testing in the future.

**END OF SECTION**
SECTION 23 02 00
BASIC MATERIALS AND METHODS FOR HVAC

PART 1 - GENERAL
1.01 GENERAL REQUIREMENTS
A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.
B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings is deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect/Engineer for review as soon as practicable. No such departures shall be made without the prior written approval of the Architect/Engineer.
C. Notwithstanding any reference in the Specifications to any article, device, product, material, fixture, form or type of construction by name, make or catalog number, such reference shall not be construed as limiting competition; and the Contractor, in such cases, may at his option use any article, device, product, material, fixture, form or type of construction which in the judgment of the Architect/Engineer, expressed in writing, is the equivalent of that specified.

1.02 SCOPE OF WORK
A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form complete and functioning systems in all of their various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The Contractor shall review all pertinent drawings, including those of other contracts, prior to commencement of Work.
B. This Division requires the furnishing and installing of all items as specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system's functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.
C. The approximate locations of Mechanical (HVAC) items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.
D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.
E. All discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to bidding. Where this cannot be done at least 7 working days prior to bid; the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.
F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.
G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".
H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.

I. The Contractor shall participate in the commissioning process as required; including, but not limited to, meeting attendance, completion of checklists, and participation in functional testing.

1.03 SCHEMATIC NATURE OF CONTRACT DOCUMENTS

A. The Contract Documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the reviewed shop drawings.

B. All duct or pipe or equipment locations as indicated on the documents do not indicate every transition, offset, or exact location. All transitions, offsets, clearances and exact locations shall be established by actual field measurements, coordination with the structural, architectural and reflected ceiling plans, and other trades. Submit shop drawings for review.

C. All transitions, offsets and relocations as required by actual field conditions shall be performed by the Contractor at no additional cost to the Owner.

D. Additional coordination with electrical contractor may be required to allow adequate clearances of electrical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.04 SITE VISIT AND FAMILIARIZATION

A. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.

B. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.

C. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.05 WORK SPECIFIED IN OTHER SECTIONS

A. Finish painting is specified. Prime and protective painting are included in the work of this Division.

B. Owner and General Contractor furnished equipment shall be properly connected to Mechanical (HVAC) systems.

C. Furnishing and installing all required Mechanical (HVAC) equipment control relays and electrical interlock devices, conduit, wire and J-boxes are included in the Work of this Division.

1.06 PERMITS, TESTS, INSPECTIONS

A. Arrange and pay for all permits, fees, tests, and all inspections as required by governmental authorities.

1.07 DATE OF SUBSTANTIAL COMPLETION

A. The date of final acceptance shall be the date of substantial completion. Refer to Division One for additional requirements.

B. The date of final acceptance shall be documented in writing and signed by the Architect, Owner and Contractor.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.

B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct - properly protected from incidental damage and weather damage.
C. Damaged equipment, duct or pipe shall be promptly removed from the site and new, undamaged equipment, pipe or duct shall be installed in its place promptly with no additional charge to the Owner.

1.09 NOISE AND VIBRATION

A. The heating, ventilating and air conditioning systems, and the component parts thereof, shall be guaranteed to operate without objectionable noise and vibration.

B. Provide foundations, supports and isolators as specified or indicated, properly adjusted to prevent transmission of vibration to the building structure, piping and other items.

C. Carefully fabricate ductwork and fittings with smooth interior finish to prevent turbulence and generation or regeneration of noise.

D. All equipment shall be selected to operate with minimum of noise and vibration. If, in the opinion of the Architect, objectionable noise or vibration is produced or transmitted to or through the building structure by equipment, piping, ducts or other parts of the Work, the Contractor shall rectify such conditions without extra cost to the Owner.

1.10 APPLICABLE CODES AND STANDARDS

A. Obtain all required permits and inspections for all work required by the Contract Documents and pay all required fees in connection thereof.

B. Arrange with the serving utility companies for the connection of all required utilities and pay all charges, meter charges, connection fees and inspection fees, if required.

C. Comply with all applicable codes, specifications, local ordinances, industry standards, utility company regulations and the applicable requirements which includes and is not limited to the following nationally accepted codes and standards:
1. Air Moving & Conditioning Association, AMCA.
2. American Standards Association, ASA.
4. American Society of Mechanical Engineers, ASME.
5. American Society of Plumbing Engineers, ASPE.
6. American Society of Testing Materials, ASTM.
7. American Water Works Association, AWWA.
8. National Bureau of Standards, NBS.
10. Sheet Metal & Air Conditioning Contractors’ National Association, SMACNA.
11. Underwriters’ Laboratories, Inc., UL.
12. International Building Code, IBC.
15. International Fuel Gas Code, IFGC.
16. International Mechanical Code, IMC.

D. Where differences existing between the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the nationally accepted codes and standards, the more stringent or costly application shall govern. Promptly notify the Engineer in writing of all differences.

E. When directed in writing by the Engineer, remove all work installed that does not comply with the Contract Documents and applicable state or city building codes, state and local ordinances, industry standards, utility company regulations and the applicable requirements of the above listed nationally accepted codes and standards, correct the deficiencies, and complete the work at no additional cost to the Owner.

1.11 DEFINITIONS AND SYMBOLS

A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 01.
B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.

C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.

E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.

F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.

G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.

H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.

I. Installer: Entity (person or firm) engaged by the Contractor, or its Subcontractor or Sub-subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.

J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe responsibilities that must be fulfilled indirectly by the Contractor or, when so noted, by other identified installers or entities.

K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as
1.12 DRAWINGS AND SPECIFICATIONS

A. These Specifications are intended to supplement the Drawings and it will not be the province of the Specifications to mention any part of the Work which the Drawings are competent to fully explain in every particular and such omission is not to relieve the Contractor from carrying out portions indicated on the Drawings only.

B. Should items be required by these Specifications and not indicated on the Drawings, they are to be supplied even if of such nature that they could have been indicated thereon. In case of disagreement between Drawings and Specifications, or within either Drawings or Specifications, the better quality or greater quantity of work shall be estimated and the matter referred to the Architect or Engineer for review with a request for information and clarification at least 7 working days prior to bid opening date for issuance of an addendum.

C. The listing of product manufacturers, materials and methods in the various sections of the Specifications, and indicated on the Drawings, is intended to establish a standard of quality only. It is not the intention of the Owner or Engineer to discriminate against any product, material or method that is the equivalent of the standards as indicated and/or specified, nor is it intended to preclude open, competitive bidding. The fact that a specific manufacturer is listed as an acceptable manufacturer should not be interpreted to mean that the manufacturer’s standard product will meet the requirements of the project design, Drawings, Specifications and space constraints.

D. The Architect or Engineer and Owner shall be the sole judge of quality and equivalence of equipment, materials and methods.

E. Products by other reliable manufacturers, other materials, and other methods, will be accepted as outlined, provided they have equivalent capacity, construction, and performance. However, under no circumstances shall any substitution be made without the written permission of the Architect or Engineer and Owner. Request for prior approval must be made in writing 10 calendar days prior to the bid date without fail.

F. Wherever a definite product, material or method is specified and there is not a statement that another product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method is the only one that shall be used without prior approval.

G. Wherever a definite material or manufacturer’s product is specified and the Specification states that products of similar design and equivalent construction from the specified list of manufacturers may be substituted, it is the intention of the Owner or Engineer that products of manufacturers that are specified are the only products that will be acceptable and that products of other manufacturers will not be considered for substitution without approval.

H. Wherever a definite product, material or method is specified and there is a statement that "OR EQUIVALENT" product, material or method will be acceptable, it is the intention of the Owner or Engineer that the specified product, material or method or an "OR EQUIVALENT" product, material or method may be used if it complies with the Specifications and is submitted for review to the Engineer as outline herein.

I. Where permission to use substituted or alternative equipment on the project is granted by the Owner or Engineer in writing, it shall be the responsibility of the Contractor or Subcontractor involved to verify that the equipment will fit in the space available which includes allowances for all required Code and maintenance clearances, and to coordinate all equipment structural support, plumbing and electrical requirements and provisions with the Mechanical (HVAC) Design Documents and all other trades, including Division 26.

J. Changes in architectural, structural, electrical, mechanical, and plumbing requirements for the substitution shall be the responsibility of the bidder wishing to make the substitution. This shall include the cost of redesign by the affected designer(s). Any additional cost incurred by affected Subcontractors shall be the responsibility of this bidder and not the Owner.
K. If any request for a substitution of product, material or method is rejected, the Contractor will automatically be required to furnish the product, material or method named in the Specifications. Repetitive requests for substitutions will not be considered.

L. The Owner or Engineer will investigate all requests for substitutions when submitted in accordance with the requirements listed above; and if accepted, will issue a letter allowing the substitutions.

M. Where equipment other than that used in the design as specified or shown on the Drawings is substituted (either from an approved manufacturers list or by submittal review), it shall be the responsibility of the substituting Contractor to coordinate space requirements, building provisions and connection requirements with his trades and all other trades; and to pay all additional costs to other trades, the Owner, the Architect or Engineer, if any, due to the substitutions.

1.13 SUBMITTALS

A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty-day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submittals shall be placed in one electronic file in PDF 8.0 format and bookmarked for individual specification sections. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:

1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.

2. An index page with a listing of all data included in the Submittal.

3. A list of variations page with a listing of all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.

4. Equipment information including manufacturer’s name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.

5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of 1/4" = 1'-0", as required to demonstrate that the alternate or substituted product will fit in the space available.

6. Identification of each item of material or equipment matching that indicated on the Drawings.

7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.

8. Additional information as required in other Sections of this Division.

9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".

B. Refer to Division 00 and Division 01 for additional information on shop drawings and submittals.
C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.

D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.

E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:

1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.

2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.

3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or Drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.

4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit. The Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or provide as noted on previous shop drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.

5. CONTRACTOR’S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor’s stamp is required stating that the submittal meets all conditions of the Contract Documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.

6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified. The Contractor will automatically be required to furnish the product, material or method named in the Specifications. Contractor shall not order equipment when submittal is marked manufacturer not as specified. Repetitive requests for substitutions will not be considered.

F. Materials and equipment which are purchased or installed without submittal review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.

G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.

H. Submittals are required for, but not limited to, the following items subject to project requirements:

1. Coordination Drawings
2. Common Motor Requirements for HVAC Equipment
3. Expansion Fittings and Loops for HVAC Piping
4. Variable Frequency Motor Speed Control for HVAC Equipment
5. Hangers and Support for Piping and Equipment HVAC
6. Vibration and Seismic Controls for HVAC Piping and Equipment
7. Testing, Adjusting, and Balancing
8. Duct Insulation
9. HVAC Equipment Insulation
10. HVAC Piping Insulation
11. Energy Management and Control System
12. Above Ground Hydronic Piping
13. Hydronic Specialties
14. Hydronic Pumps
15. Metal Ductwork
16. Ductwork Accessories
17. HVAC Fans
18. Air Distribution Devices
19. Air Filters
20. Packaged Air Handling Unit
21. Modular Outdoor Central Station Air Handling Units

I. Refer to other Division 23 sections for additional submittal requirements. Provide samples of actual materials and/or equipment to be used on the Project upon request of the Owner or Engineer.

1.14 COORDINATION DRAWINGS

A. Prepare coordination drawings to a scale of 1/4"=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
   a. Wall and type locations.
   b. Clearances for installing and maintaining insulation.
   c. Locations of light fixtures and sprinkler heads.
   d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
   e. Equipment connections and support details.
   f. Exterior wall and foundation penetrations.
   g. Routing of storm and sanitary sewer piping.
   h. Fire-rated wall and floor penetrations.
   i. Sizes and location of required concrete pads and bases.
   j. Valve stem movement.
   k. Structural floor, wall and roof opening sizes and details.

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

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

4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.

C. By submitting coordination drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.15 RECORD DOCUMENTS

A. Prepare Record Documents in accordance with the requirements of Division 00 and Division 01, in addition to the requirements specified in Division 23.
B. The Contractor shall maintain a separate set of clearly and legibly marked Record Drawings on the job site to record all changes and modifications, including, but not limited to the following: work details, alterations to meet site conditions, and changes made by “Change Order” notices. Mark the drawings with colored pencil(s). These shall be available for review by the Owner, Architect or Engineer during the entire construction stage.

C. The Record Drawings shall be updated concurrently as construction progresses, and in no case less frequently than a daily basis. They shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents. All dimensions shall include at least two dimensions to permanent structure points.

D. Record Drawings shall indicate, at a minimum, the following installed conditions:

1. Duct mains and branches, size and location, for both exterior and interior; locations of dampers, fire dampers, duct access panels, and other control devices; filters, fuel fired heaters, fan coils, condensing units, and roof-top A/C units requiring periodic maintenance or repair.

2. Mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., traps, strainers, expansion compensators, tanks, etc.). Valve location diagrams, complete with valve tag chart. Indicate actual inverts and horizontal locations of underground piping.

3. Equipment locations (exposed and concealed), dimensioned from prominent building lines.


5. Contract Modifications, actual equipment and materials installed.

E. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified herein to record the locations and invert elevations of underground installations.

F. If the Contractor does not keep an accurate set of Record Drawings, the pay request may be altered or delayed at the request of the Architect. Delivery of Record Documents is a condition of final acceptance. Record Drawings shall be furnished in addition to Shop Drawings.

G. The Contractor shall submit an electronic copy of the record documents in PDF format and one (1) full size set of Record Drawing prints to the Architect or Engineer for review prior to scheduling the final inspection at the completion of the work. The drawings shall have the name(s) and seal(s) of the Engineer(s) removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS
DATE:
(NAME OF GENERAL CONTRACTOR)
BY: ____________________________
(SIGNATURE)
(NAME OF SUBCONTRACTOR)
BY: ____________________________
(SIGNATURE)

OPERATING AND MAINTENANCE MANUALS

H. Prepare operating and maintenance manuals in accordance with Division 00 and Division 01 and, in addition to the requirements specified in those Divisions, include the following information for equipment items:

1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   a. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown,
and emergency instructions; and summer and winter operating instructions.

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

c. Servicing instructions and lubrication charts and schedules.

I. CERTIFICATIONS AND TEST REPORTS
1. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and scheduled date for each test. This detailed completion and test schedule shall be submitted at least 90 days before the projected substantial completion date.

2. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule.

3. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of substantial completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.

4. Certifications and test reports to be submitted shall include, but not be limited to, those items outlined in Section 23 02 00.

J. OPERATING AND MAINTENANCE MANUALS
1. Prepare Operations and Maintenance manuals in accordance with the requirements of Division 01 and Division 23. In addition to the requirements of other Sections, this shall include the following information for equipment items:
   a. Identifying names, name tags designations and locations for all equipment.
   b. Valve tag lists with valve number, type, color coding, location and function.
   c. Reviewed Shop Drawing submittals with exceptions noted compliance letter.
   d. Fabrication drawings.
   e. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.
   f. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   g. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   h. Servicing instructions and lubrication charts and schedules.
   i. Equipment and motor name plate data.
   j. Wiring diagrams.
   k. Exploded parts views and parts lists for all equipment and devices.
   l. Color coding charts for all painted equipment and conduit.
   m. Location and listing of all spare parts and special keys and tools furnished to the Owner.
   n. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.

2. Coordinate with Division 01 for Operations and Maintenance manual requirements. Unless noted otherwise, bind together in "D ring" style three-ring binders (National model no. 79-883 or equivalent). Binders shall be large enough to allow ¼" of spare capacity. Include three (3) sets with all approved Shop Drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections with tabbed insertable dividers, labeled for easy reference. Utilize the individual specification section numbers shown in the Mechanical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 23 shall be clearly and legibly set forth in memoranda that shall, likewise,
be bound with bulletins.
3. In addition to the bound “hard-copy” Operation and Maintenance manuals referenced above, provide an identical electronic copy in searchable PDF format, with all sections bookmarked within the file for easy reference. Provide a USB flash drive with the final manual to the Owner.
4. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer for review a minimum of fourteen (14) working days prior to the beginning of the operator training period.
5. Operating and Maintenance Manuals which the Engineer deems incomplete, poorly organized, or otherwise unacceptable will be rejected in writing. The Contractor will subsequently be required to again turn over Operating and Maintenance Manuals, with all deficiencies corrected, until deemed acceptable by the Engineer.

K. OPERATOR TRAINING
1. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include a minimum of 12 hours of onsite training in three (3) shifts of four (4) hours each.
2. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period, obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.
3. Refer to other Division 23 Sections for additional Operator Training requirements.

L. FINAL COMPLETION
1. At the completion of the Work, all equipment and systems shall be tested and faulty equipment and material shall be repaired or replaced. Refer to Sections of Division 23 for additional requirements.
2. Clean and adjust all air distribution devices and replace all air filters immediately prior to Substantial Completion.
3. Touch up and/or refinish all scratched equipment and devices immediately prior to Substantial Completion.

M. CONTRACTOR'S GUARANTEE
1. Use of the HVAC systems to provide temporary service during construction period will not be allowed without permission from the Owner in writing; and, if granted, shall not cause the warranty period to start, except as defined below.
2. Contractor shall guarantee to keep the entire installation in repair and perfect working order for a period of one year after the date of the Substantial Completion, and shall furnish (free of additional cost to the Owner) all materials and labor necessary to comply with the above guarantee throughout the year beginning from the date of Substantial Completion, Beneficial Occupancy by the Owner, or the Certificate of Final Payment as agreed upon by all parties.
3. This guarantee shall not include cleaning or changing filters except as required by testing, adjusting and balancing.
4. All air conditioning compressors shall have parts and labor guarantees provided by the equipment manufacturer for a period of not less than 5 years beyond the date of Substantial Completion.
5. Refer to Sections in Division 23 for additional guarantee or warranty requirements.

N. TRANSFER OF ELECTRONIC FILES
1. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner’s risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney’s fees arising out of or resulting thereof.
2. Because data stored in electronic media format can deteriorate or be modified inadvertently, or otherwise, without authorization of the data’s creator, the party receiving the electronic files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed
PART B - EQUIPMENT

2.01 MATERIALS
A. Provide materials and equipment manufactured by a domestic United States manufacturer and assembled in the United States for all local and Federal Government projects. These materials and equipment shall comply with "Buy American Act."
B. Access Doors: Provide access doors as required for access to equipment, valves, controls, cleanouts and other apparatus where concealed. Access doors shall have concealed hinges and screw driver cam locks.
C. All access doors located in wet areas such as restrooms, locker rooms, shower rooms, kitchen and any other wet areas shall be constructed of stainless steel.
D. Access Doors: shall be as follows:
   1. Plaster Surfaces: Milcor Style K.
   2. Ceramic Tile Surface: Milcor Style M.
   3. Drywall Surfaces: Milcor Style DW.
   4. Install doors only in locations approved by the Architect.

2.02 EQUIPMENT PADS
A. Provide 4-inch-high concrete pads for indoor floor mounted equipment. Pads shall conform to the shape of the equipment with a minimum extension of 6 inch beyond the equipment on all sides. Top and sides of pads shall be troweled to a smooth finish, equivalent to the floor. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.
B. Provide 6-inch-high concrete pads for all exterior mounted equipment. Pads shall conform to the shape of the equipment with a minimum extension of 6 inch beyond the equipment on all sides. Provide a 4-foot monolithic extension to the pad in front of the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.) Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.

to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.
3. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.
4. Any reuse or modifications will be at the Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.
5. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.
   a. It is agreed that "MEP" hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The Contract Documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement Between Architect and Owner.
   b. If the client, Architect or Owner of the project requires electronic media for "record purposes", then AutoCAD/ Revit documents will be prepared by Engineer on electronic media such as removable memory devices, flash drives or CD's. These documents can also be submitted via file transfer protocols. AutoCAD/ Revit files will be submitted with all title block references intact to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.
   c. At the Architect/Owner's request, Engineer will assist the Contractor in the preparation of the submittals and prepare one copy of AutoCAD/ Revit files on electronic media or submit through file transfer protocols. The electronic media will be prepared with all indicia of documents ownership removed. The electronic media will be prepared in a " .rvt " or " .dwg " format to permit the end user to revise the drawings.

PART 2 - PRODUCTS
PART 3 - EXECUTION

3.01 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected via reviewed submittals.

B. Refer to equipment specifications in Divisions 2 through 48 for additional rough-in requirements.

3.02 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
   1. Coordinate mechanical systems, equipment, and materials installation with other building components.
   2. Verify all dimensions by field measurements.
   3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
   4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
   5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
   7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
   8. Install systems, materials, and equipment to conform with architectural action markings on submittal, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, resolve conflicts and submit proposed solution to the Architect for review.
   9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
   10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as possible, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and label.
   11. Install access doors where units are concealed behind finished surfaces. Refer to paragraph 2.1 in this section and architect for access doors specifications and location.
   12. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
   13. Provide roof curbs for all roof mounted equipment. Coordinate with roof construction for pitched roof. Provide roof curbs which match the roof slope and provides a level top for equipment installation. Refer to Architectural drawings and details.
   14. The equipment to be furnished under these Specifications shall be essentially the standard product of the manufacturer. Where two or more units of the same class of equipment are required, these units shall be products of a single manufacturer; however, the component parts of the system need not be the product of the same manufacturer.
   15. The Architectural and Structural features of the building and the space limitations shall be considered in selection of all equipment. No equipment shall be furnished which will not suit the arrangement and space limitations indicated.
   16. Lubrication: Prior to start-up, check and properly lubricate all bearings as recommended by the manufacturer.
   17. Where the word "Concealed" is used in these Specifications in connection with insulating, painting, piping, ducts, etc., it shall be understood to mean hidden from sight as in chases, furred spaces or suspended ceilings. "Exposed" shall be
understood to mean the opposite of concealed.

18. Identification of Mechanical Equipment:
   a. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.
   b. Tags shall be attached to all valves, including control valves, with nonferrous chain. Tags shall be brass and at least 1-1/2 inches in diameter. Nameplate and tag symbols shall correspond to the identification symbols on the temperature control submittal and the "as-built" drawings.

19. Provide construction filters for all air handling units, fan coil unit, VAV boxes, and all other air handling equipment during the entire construction period.

20. Provide temporary construction strains for all strainers in the hydronic systems during the initial flushing of the systems.

3.03 CUTTING AND PATCHING

A. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.

B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
   1. Uncover Work to provide for installation of ill-timed Work.
   2. Remove and replace defective Work.
   3. Remove and replace Work not conforming to requirements of the Contract Documents.
   4. Remove samples of installed Work as specified for testing.
   5. Install equipment and materials in existing structures.
   6. Upon written instructions from the Engineer, uncover and restore Work to provide for Engineer/Owner's observation of concealed Work, without additional cost to the Owner.
   7. Patch existing finished surfaces and building components using new materials matching existing materials and experienced Installers. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers; refer to the materials and methods required for the surface and building components being patched; Refer to Paragraph 1.11 I for definition of "Installer."

C. Cut, remove and legally dispose of selected mechanical equipment, components, and materials as indicated, including but not limited to removal of mechanical piping, mechanical ducts and HVAC units, and other mechanical items made obsolete by the new Work.

D. Protect the structure, furnishings, finishes, and adjacent materials not indicated or scheduled to be removed.

E. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.

3.04 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER, ARCHITECT AND ENGINEER

A. The Owner will cooperate with the Contractor, however, the following provisions must be observed:
   1. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Sub-Contractors and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.
   2. During the construction of this project, normal facility activities will continue in existing buildings until renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
   3. Contractor shall not start-up any of the HVAC equipment unless the Owner, Architect and Engineer are signed off.
4. Start-up for major HVAC equipment such as chillers, cooling towers, variable frequency drives and hot water boilers shall be performed by a factory technician. The start-up shall include a written report signed off by Contractor, Engineer and Owner.

3.05 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS

A. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to, the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the contractor, who shall produce drawings that shall be submitted to the Architect/Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.

B. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Architect/Engineer for review.

C. All equipment and/or systems noted on the Drawings "To Be Removed" shall be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.

D. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building. None of the construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.

E. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.

F. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.

G. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.

H. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage that occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.

I. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the Drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.

J. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.

K. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in
proper operating condition.

L. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owner’s representative in order to protect systems that shall remain in service.

M. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.

N. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

END OF SECTION
SECTION 23 02 01

COORDINATION DRAWINGS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions 013100 and Supplementary Conditions apply to all Work herein.

1.02 COORDINATION DRAWINGS

A. The Contractor shall take the lead in coordinating the Mechanical, Electrical, Plumbing, Communications, Electronic Safety/Security and Fire Protection systems within the building.

B. The Contractor shall coordinate a three-dimensional (3D) model of the building which includes the Mechanical, Electrical, Plumbing, and Fire Protection systems. The Contractor will be provided with the REVIT model that was used to generate the contract documents, this file may be used as the background file. The Contractor shall replace the systems drawn with the actual shop drawing models. The Contractor is not limited to using REVIT and may use any 3D software in generating and combining the coordination model.

C. Submitting the contract drawings as coordination drawings will not be acceptable.

D. The model shall include detailed and accurate representations of all equipment to be installed based upon the reviewed equipment submittals.

E. The Contractor shall hold a 3-D coordination meeting with all sub-contractors present to review the model and discuss coordination of the installation of the building systems.

F. Upon completion of the coordination meeting, the Contractor shall submit the 3-D model and 1/4" scale drawings for review.

G. The model shall detail major elements, components, and systems in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

H. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
   1. Wall and type locations.
   2. Clearances for installing and maintaining insulation.
   3. Locations of light fixtures and sprinkler heads.
   4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
   5. Equipment connections and support details.
   7. Routing of storm and sanitary sewer piping.
   8. Fire-rated wall and floor penetrations.
   9. Sizes and location of required concrete pads and bases.
  11. Structural floor, wall and roof opening sizes and details.

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

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

K. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

L. Sequence of Coordination - Below is hierarchy of model elements and the sequencing by which the models will be coordinated.
   1. Structural and Architectural model
   2. Miscellaneous steel
3. Perform preliminary space allocation
4. Identify hard constraints (locations of access panels, lights, A/V space requirements, etc.)
5. Main and medium pressure ducts from the shaft out
6. Main graded plumbing lines and vents
7. Sprinkler mains and branches
8. Cold and hot water mains and branches
9. Lighting fixtures and plumbing fixtures
10. Smaller sized ducts and flex ducts
11. Smaller size cold water and hot water piping, flex ducts, etc.

M. The Contractor shall not install any item until the coordination has been completed and reviewed by the Construction Manager, Owner, and A/E team.

N. The Contractor shall be responsible for coordination of all items that will affect the installation of the work. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.

O. By submitting shop drawings on the project, the Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all trades.

END OF SECTION
SECTION 23 03 00
MECHANICAL DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.01 SECTION INCLUDES
A. Mechanical demolition.
B. The Drawings do not show all demolition work required. The Contractor shall make himself familiar with the required scope of work to accomplish the work required by these documents. All demolition work implied or required shall be included in the scope of this contract.
C. Utility service outages required by the new installation will be permitted but only at a time approved by the Owner. The Contractor shall allow the Owner 2 weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

1.02 RELATED SECTIONS
A. Section 02 40 00 - Demolition and Structure Moving.

1.03 WORK SEQUENCE, TIMING, COORDINATION WITH OWNER
A. The Owner will cooperate with the Contractor; however, the following provisions must be observed:
1. During the construction of this project, normal facility activities will continue in existing buildings until new buildings or renovated areas are completed. Plumbing, fire protection, lighting, electrical, communications, heating, air conditioning, and ventilation systems shall be maintained in service within the occupied spaces of the existing building.
2. A meeting will be held at the project site, prior to any construction, between the Owner's Representative, the General Contractor, the Subcontractors and Sub-subcontractors, and the Engineer to discuss Contractor's employee parking space, access, storage of equipment or materials, and use of the Owner's facilities or utilities. The Owner's decisions regarding such matters shall be final.

1.04 DEMOLITION AND WORK WITHIN EXISTING BUILDINGS
A. In the preparation of these documents every effort has been made to show the approximate locations of, and connections to the existing piping, duct, equipment and other apparatus related to this phase of the Work. However, this Contractor shall be responsible for verifying all of the above information. This Contractor shall visit the existing site to inspect the facilities and related areas. This Contractor shall inspect and verify all details and requirements of all the Contract Documents, prior to the submission of a proposal. All discrepancies between the Contract Documents and actual job-site conditions shall be resolved by the contractor, who shall produce drawings which shall be submitted to the Architect/Engineer for review. All labor and materials required to perform the work described shall be a part of this Contract.
B. All equipment and/or systems noted on the Drawings "To Remain" shall be inspected and tested on site to certify its working condition. A written report on the condition of all equipment to remain, including a copy of the test results and recommended remedial actions and costs shall be made by this Contractor to the Architect/Engineer for review.
C. All equipment and/or systems noted on the Drawings "To Be Removed" should be removed including, associated pipe and duct, pipe and duct hangers and/or line supports. Where duct or pipe is to be capped for future or end of line use, it shall be properly tagged with its function or service appropriately identified. Where existing equipment is to be removed or relocated and has an electric motor or connection, the Electrical Contractor shall disconnect motor or connection, remove wiring to a safe point and this Contractor shall remove or relocate motor or connection along with the equipment.
D. During construction and remodeling, portions of the Project shall remain in service. Construction equipment, material, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building. None of the
construction work shall interfere with the proper operation of the existing facility; or be so conducted as to cause harm or danger to persons on the premises. All fire exits, stairs or corridors required for proper access, circulation or exit shall remain clear of equipment, materials or debris. The General Contractor shall maintain barricades, other separations in corridors and other spaces where work is conducted.

E. Certain work during the demolition and construction phases may require overtime or night time shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner at least seventy-two (72) hours in advance in writing.

F. Any salvageable equipment as determined by the Owner, shall be delivered to the Owner, and placed in storage at the location of his choice. All other debris shall be removed from the site immediately.

G. Equipment, piping or other potential hazards to the occupants of the building shall not be left overnight outside of the designated working or construction area.

H. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch or replace as required any damage which occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction and to keep construction disrupted areas to a minimum. Coordinate with the Owner and other trades in scheduling and performance of the work.

I. Include in the contract price all rerouting of existing pipe, duct, etc., and the reconnecting of the existing equipment as necessitated by field conditions to allow the installation of the new systems regardless of whether or not such rerouting, reconnecting or relocating is shown on the drawings. Furnish all temporary pipe, duct, controls, etc., as required to maintain heating, cooling, and ventilation services for the existing areas with a minimum of interruption.

J. All existing pipe, duct, materials, equipment, controls and appurtenances not included in the remodel or alteration areas are to remain in place.

K. Pipe, duct, equipment and controls serving mechanical and other Owner's equipment, etc., which is to remain but which is served by pipe, duct, equipment and controls that are disturbed by the remodeling work, shall be reconnected in such a manner as to leave this equipment in proper operating condition.

L. No portion of the fire protection systems shall be turned off, modified or changed in any way without the express knowledge and written permission of the Owner's representative in order to protect systems that shall remain in service.

M. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and operating system in cooperation with other trades with a minimum of disruption or downtime.

N. Refer to Architectural Demolition and/or Alteration plans for actual location of walls, ceilings, etc., being removed and/or remodeled.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Field verify measurements, and piping arrangements are as shown on Drawings.

B. Verify that abandoned piping and equipment serve only abandoned facilities.

C. Demolition Drawings are based on casual field observation and existing Record Documents. Report discrepancies to Architect and Engineer before disturbing existing installation.

D. Beginning of demolition means that the contractor accepts existing conditions.

3.02 PREPARATION

A. Disconnect mechanical systems in walls, floors, and ceilings scheduled for removal.

B. Coordinate utility service outages with Utility Company.
C. Provide temporary connections, if required, to maintain existing systems in service during construction. When work must be performed on energized equipment, use personnel experienced in such operations.

D. Existing Service: 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 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner and local fire service at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.03 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK
A. Demolish and extend existing mechanical work under provisions of Division 02 and this Section.
B. Remove, relocate, and extend existing systems to accommodate new construction.
C. Remove abandoned piping to source of supply.
D. Remove exposed abandoned piping systems, including abandoned systems above accessible ceiling finishes. Cut systems flush with walls and floors, and patch surfaces.
E. Repair adjacent construction and finishes damaged during demolition and extension work.
F. Maintain access to existing systems which remain active. Modify installation or provide access doors as appropriate.
G. Extend existing systems using materials and methods compatible with existing systems, or as specified.

3.04 CLEANING AND REPAIR
A. Clean and repair existing materials and equipment which remain or are to be reused.

3.05 INSTALLATION
A. Install relocated materials and equipment under the provisions of Division 02.

3.06 REMOVAL OF MATERIALS
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. Materials and/or items scheduled for relocation and which are damaged during dismantling or reassembly operations shall be repaired and restored to good operating condition. The Contractor may, at his discretion and upon the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.
B. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore 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 are found to be in damaged condition before work has been started on dismantling, the Contractor shall call the attention of the Owner 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, at no additional cost to the Owner.
D. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the Drawings, specified, or acceptable to the Owner. Service lines and wiring 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 Owner. 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 which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

E. Certain work during the demolition and construction phases may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner's Representative at least 72 hours in advance in writing.

F. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch, or replace as required any damage which occurs as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction. Cooperate with the Owner and other trades in scheduling and performance of the work.

G. See Paragraph I on page 23 02 00 – 18

H. The Contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing such loss or damage. The Contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all electrical services for the new and existing facilities. The Contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

I. Where existing construction is removed to provide working and extension access to existing utilities, Contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.

J. Where partitions, walls, floors, or ceilings of existing construction are being removed, all contractors shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction.

END OF SECTION
SECTION 23 05 13

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 SCOPE
A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
B. WORK SPECIFIED ELSEWHERE:
   1. Painting
   2. Automatic temperature controls
   3. Power control wiring to motors and equipment

1.03 WARRANTY
A. Warrant the Work specified herein for one year and motors for five years beginning on the date of substantial completion.

1.04 REFERENCE STANDARDS
B. NEMA MG 1 - Motors and Generators.

1.05 SUBMITTALS
A. SHOP DRAWINGS: Indicate size material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures variations, and accessories.
C. MOTOR NAMEPLATE INFORMATION: Manufacturer's name, address, utility and operating data.
D. Refer to Division One for additional information.

1.06 DELIVERY AND STORAGE
A. DELIVERY: Deliver clearly labeled, undamaged materials in the manufacturers' unopened containers.
B. TIME AND COORDINATION: Deliver materials to allow for minimum storage time at the project site. Coordinate delivery with the scheduled time of installation.
C. STORAGE: Store materials in a clean, dry location, protected from weather and abuse.

PART 2 - PRODUCTS

2.01 ELECTRIC MOTORS
A. APPROVED MANUFACTURERS: Provide motors by a single manufacturer as much as possible.
   1. Baldor
   2. Marathon
   3. Siemens-Allis
   4. General Electric
   5. U.S. Motor
B. TEMPERATURE RATING: Provide insulation as follows:
   1. CLASS B: 40 degrees C maximum.
   2. CLASS F:
      a. Between 40 degrees C and 65 degrees C maximum.
      b. Totally enclosed motors.
C. STARTING CAPABILITY: As required for service indicated five starts minimum per hour.

D. PHASES AND CURRENT: Verify electrical service compatibility with motors to be used.
   1. UP TO 3/4 HP: Provide electronically commutated brushless DC single phase motors with built-in inverter and microprocessor-based control.
   2. 1 HP AND LARGER: Provide squirrel-cage AC induction polyphase motors.
   3. Name plate voltage shall be the same as the circuit’s nominal voltage, serving the motor.

E. SERVICE FACTOR: 1.15 for polyphase; 1.35 for single phase.

F. FRAMES: U-frames 1.5 hp. and larger.

G. BEARINGS: Provide sealed re-greaseable ball bearings; with top mounted Zerk lubrication fittings and bottom side drains minimum average life 100,000 hours typically, and others as follows:
   1. Design for thrust where applicable.
   2. PERMANENTLY SEALED: Where not accessible for greasing.
   3. SLEEVE-TYPE WITH OIL CUPS: Light duty fractional hp. motors or polyphase requiring minimum noise level.

H. ENCLOSURE TYPE: Provide enclosures as follows:
   1. CONCEALED INDOOR: ODP (Open Drip Proof).
   2. EXPOSED INDOOR: Guard Protected.
   3. OUTDOOR TYPICAL: Type II. TEFC.
   4. OUTDOOR WEATHER PROTECTED: Type I. WPI.
   5. EXPLOSION PROOF, XP: For use in hazardous locations.

I. OVERLOAD PROTECTION: Built-in sensing device for stopping motor in all phase legs and signaling where indicated for fractional horse power motors.

J. NOISE RATING: "Quiet" except where otherwise indicated.

K. EFFICIENCY: Minimum full load efficiency listed in the following table, when tested in accordance with IEEE 112, Method B, including stray load loss measure.

<table>
<thead>
<tr>
<th>Motor horsepower</th>
<th>Index Letter</th>
<th>Minimum Efficiency</th>
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<tbody>
<tr>
<td>3 - 5</td>
<td>G</td>
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<tr>
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<tr>
<td>150 - 200</td>
<td>B</td>
<td>95.8</td>
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</tbody>
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NEMA MG 1 Efficiency - 1800 RPM Synchronous Speed
### 2.02 MOTOR CONTROLLERS (STARTERS)

A. All motor controllers (for equipment furnished under Division 23) shall be furnished under Division 23 and installed under Division 26 unless otherwise noted on the plans.

1. Starters shall be provided for 3 phase motors 1 horsepower and greater.

B. Motor starters shall be furnished as follows.

1. **GENERAL:** Motor starters shall be Square D Company Class 8536 across-the-line magnetic type, full-voltage, non-reversing (FAVOR) starter. All starters shall be constructed and tested in accordance with the latest NEMA standards, sizes and horsepower. ICE sizes are not acceptable. Starters shall be mounted in a general purpose dead front, painted steel enclosure and surface-mounted. Provide size and number of poles as shown and required by equipment served. Provide two speed, two winding or two speed, single winding motor starter as required for two speed motors.

2. **CONTACTS:** Magnetic starter contacts shall be double break solid silver alloy. All contacts shall be replaceable without removing power wiring or removing starter from panel. The starter shall have straight-through wiring.

3. **OPERATING COILS:** Operating coils shall be 120 volts and shall be of molded construction. When the coil fails, the starter shall open and shall not lock in the closed position.

4. **OVERLOAD RELAYS:** Provide manual reset, trip-free Class 20 overload relays in each phase conductor in of all starters. Overload relays shall be melting alloy type with visual trip indication. All 3 phase and single phase starters shall have one overload relay in each underground conductor. Relay shall not be field adjustable from manual to automatic reset. Provide 6 overload relays for two speed motor starters.

5. **PILOT LIGHTS:** Provide a red running pilot light for all motor starters. Pilot lights shall be mounted in the starter enclosure cover. Pilot lights shall be operated from an interlock on the motor starter and shall not be wired across the operating coil.

6. **CONTROLS:** Provide starters with HAND-OFF-AUTOMATIC switches. Coordinate additional motor starter controls with the requirements of Division 23. Motor starter controls shall be mounted in the starter enclosure cover.

7. **CONTROL POWER TRANSFORMER:** Provide a single-phase 480 volt control power transformer with each starter for 120 volt control power. Connect the primary side to the line side of the motor starter. The primary side shall be protected by a fuse for each conductor. The secondary side shall have one leg fused and one leg grounded. Arrange transformer terminals so that wiring to terminals will not be located above the transformer.

8. **AUXILIARY CONTACTS:** Each starter shall have one normally open and one normally closed convertible auxiliary contact in addition to the number of contacts required for the "holding interlock", remote monitoring, and control wiring. In addition, it shall be possible to field-install three more additional auxiliary contacts without removing existing wiring or removing the starter from its enclosure.

9. **UNIT WIRING:** Unit shall be completely pre-wired to terminals to eliminate any interior field wiring except for line and load power wiring and HVAC control wiring.

<table>
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<tbody>
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</table>
10. ENCLOSURES: All motor starter enclosures shall be NEMA 1, general purpose enclosures or NEMA-3R if mounted exposed to high moisture conditions. Provide NEMA 4X when located by cooling towers.

11. POWER MONITOR: Provide a square "D" 8430 MPS phase failure and under-voltage relay, base and wiring required for starters serving all 3 phase motors. Set the under-voltage setting according to minimum voltage required for the motor to operate within its range.

C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
   1. Siemens.
   2. Square D.
   4. Eaton.

2.03 COMBINATION MOTOR STARTERS

A. GENERAL: Combination motor starters shall consist of a magnetic starter and a fusible or non-fusible disconnect switch in a dead front, painted steel NEMA 1 enclosure unless otherwise noted and shall be surface-mounted. Size and number of poles shall as shown and required by equipment served. Combination motor starters shall be as specified for motor starters in Paragraph 2.02-B, except as modified herein.

B. DISCONNECT SWITCH: Disconnect switches shall be as specified in Section 26 28 16.

C. APPROVED MANUFACTURERS: Controller numbers are based on first named manufacturer. Provide one of the following manufacturer's.
   1. Siemens.
   2. Square D.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All equipment shall be installed in accordance with the manufacturers' recommendations and printed installation instructions.

B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors' price shall include all items required as per manufacturers’ requirements.

C. Install in a professional manner. Any part or parts not meeting this requirement shall be replaced or rebuilt without extra expense to Owner.

D. Install rotating equipment in static and dynamic balance.

E. Provide foundations, supports, and isolators properly adjusted to allow minimum vibration transmission within the building.

F. Correct objectionable noise or vibration transmission in order to operate equipment satisfactorily as determined by the Engineer.

END OF SECTION
SECTION 23 05 16

EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
   A. Flexible pipe connections.
   B. Expansion joints and compensators
   C. Pipe loops, offsets, and swing joints.

1.03 RELATED WORK
   A. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
   B. Section 23 21 13 - Above Ground Hydronic Piping
   C. Section 23 22 13 - Steam and Condensate Heating Piping
   D. Section 23 23 00 - Refrigerant Piping

1.04 PERFORMANCE REQUIREMENTS
   A. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
   B. Expansion Calculations:
      1. Installation Temperature: 50 degrees F (10 degrees C).
      3. Domestic Hot Water: 140 degrees F (60 degrees C).
      4. Safety Factor: 30 percent.
   C. Pipe sizes indicated are to establish a minimum quality of compensator. Refer to manufacturer’s literature for model series for different pipe sizes.

1.05 SUBMITTALS
   A. Submit shop drawings under provisions of Division One.
   B. Product Data:
      1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face-to-face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
      2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
   C. Design Data: Indicate selection calculations.
   D. Manufacturer’s Installation Instructions: Indicate special procedures, and external controls.

1.06 PROJECT RECORD DOCUMENTS
   A. Submit under provisions of Division One.
   B. Record actual locations of flexible pipe connectors, expansion joints, anchors, and guides.

1.07 OPERATION AND MAINTENANCE DATA
   A. Submit under provisions of Division One.
   B. Maintenance Data: Include adjustment instructions.

1.08 QUALIFICATIONS
   A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum five years documented experience.
B. Design expansion compensation system under direct supervision of a Professional Engineer experienced in design of this work and licensed in the state where the project is located.

1.09 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products under provisions of Division One.
B. Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
C. Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.10 WARRANTY
A. Provide five year warranty under provisions of Division One.
B. Warranty: Include coverage for leak free performance of packed expansion joints.

1.11 EXTRA MATERIALS
A. Furnish under provisions of Division One.

PART 2 - PRODUCTS
2.01 FLEXIBLE PIPE CONNECTORS
A. Steel Piping (Based on 2” Pipe):
   1. Manufacturers:
      a. Amber/Booth Metal-Flex, Model Type SS-PM or FW
      b. Triplex, Model Flexonics Series 400M
      c. Mercer Rubber Company, Model BSS-EM (Mason Industries)
   2. Inner Hose: Type 321, stainless steel, corrugated metal.
   4. Pressure Rating: 350 psig WOG and 70 degrees F. For 4 inch pipe - 200 psig WOG and 70 degrees F.
   5. Joint: Schedule 40 steel, threaded with male nipple and hex boss each end and union. Flanged joints for pipe sizes 2½ inch and larger.
   7. Maximum offset: 1/2 inch on each side of installed center line.
   8. Application: Air handling unit cooling and heating coils.
B. Copper Piping (Based on 2” Pipe):
   1. Manufacturers:
      a. Amber/Booth Metal-Flex, Model Type BR-SM
      b. Triplex, Model Flexonics Series 300
      c. Mercer Rubber Company, Type BFF (Mason Industries)
   2. Inner Hose: Corrugated Bronze
   4. Pressure Rating: 250 psig WOG and 70 degrees F.
   5. Joint: Threaded with male nipple and hex boss each end with union. Flanged joints for pipe sizes 2½ inch and larger.
   7. Maximum offset: 1/2 inch on each side of installed center line.
   8. Application: Air handling unit cooling and heating coils.

2.02 EXPANSION JOINTS
A. Bellows Type (Based on 4” Pipe):
   1. Manufacturers:
      a. Amber/Booth, Style EB
      b. Triplex, Model Resistoflex R6905
      c. Mercer Rubber Company, Style 803 or 805 (Mason Industries)
   2. Body: Monel wire reinforced molded TFE teflon bellows, multiple arch.
   3. Pressure Rating: 70 psig WSP and 250 degrees F (66 degrees C).
   4. Maximum Compression: 1 inch.
   5. Maximum Extension: 1 inch.
8. Size: Use pipe sized units.
9. Accessories: Control rod limit bolts.
10. Application: Steel piping 8 inch and under.

2.03 ACCESSORIES
A. Pipe Alignment Guides to Direct Axial Movement:
   1. Manufacturers:
      a. Triplex, Model Flexonics
      b. Metraflex, Style II
   2. Two piece welded steel with shop paint, and bolted to fit standard pipe, frame with four mounting holes, clearance for minimum 1 inch thick insulation, minimum 3 inch travel.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Install in accordance with manufacturer’s instructions.
B. Construct spool pieces to exact size of flexible connection for future insertion.
C. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provided line size flexible connectors.
D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
E. Provide miscellaneous metals to rigidly anchor pipe to building structure. Provide pipe guides so that movement takes place along axis of pipe only. Erect piping such that strain and weight is not on cast connections or apparatus.
F. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets, and swing joints, or expansion joints where required.

3.02 MANUFACTURER’S FIELD SERVICES
A. Prepare and start systems under provisions of Division One.
B. Provide inspection services by flexible pipe manufacturer’s representative for final installing and certify installation is in accordance with manufacturer’s recommendations and connectors are performing satisfactorily.

END OF SECTION
SECTION 23 05 26

VARIABLE FREQUENCY MOTOR SPEED CONTROL FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. Section 1.1 A in Section 23 05 13
B. Section 1.1 B in Section 23 05 13
C. Furnish and install a complete adjustable frequency motor speed control for the following items:
   1. Variable volume air handling units.
   2. Hot water pumps
   3. Variable volume ventilation fans.

1.02 RELATED SECTIONS
A. Section 23 02 00 - Basic Materials and Methods for HVAC
B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
C. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
D. Section 23 05 93 - Testing, Adjusting, And Balancing
E. Section 23 09 63 - Energy Management and Control System (EMCS)
F. Section 23 21 23 - Hydronic Pumps
G. Section 23 73 13 - Modular Indoor Central Station Air Handling Units

1.03 REFERENCES
B. ISO 9001 - Quality management systems -- Requirements.
C. NFPA 70 - National Electrical Code.
D. UL 508 - Industrial Control Equipment.

1.04 SUBMITTALS
A. Submit shop drawings and product data under provisions of Division One.
B. Certified noise data shall be submitted by drive manufacturer. Noise generated by variable frequency motor speed control drive shall not exceed preferred “RC” as listed in 2019 ASHRAE (HVACA), Chapter 49 Noise and Vibration Control, Table 2 Criteria for Acceptable HVAC Noise in Unoccupied Rooms.

1.05 WARRANTY
A. Warranty shall be 24 months from the date of certified start-up, not to exceed 30 months from the date of shipment. The warranty shall include all parts, labor, travel time and expenses. There shall be 365/24 support available via a toll-free phone number.

1.06 DELIVERY, STORAGE AND HANDLING
A. Equipment shall be stored and handled per manufacturer's instructions.

1.07 OPERATIONS PERSONNEL TRAINING
A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.
PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. ABB
B. Yaskawa/Magnetek
C. Danfoss

2.02 ADJUSTABLE FREQUENCY INVERTER

A. The AFD package as specified herein shall be enclosed in a NEMA 12 enclosure for interior applications, a NEMA 3R enclosure for exterior locations and a NEMA 4X enclosure where located in a cooling tower yard or within 20 feet from cooling tower. All enclosures shall be completely assembled and tested by the manufacturer in an ISO 9001 facility. The AFD shall operate from a line of +30% over nominal and the under-voltage trip level shall be 35% under the nominal voltage as a minimum.

B. The fused input shall utilize fast acting current limiting type per manufacturer recommendations.

C. The variable frequency power and logic unit shall be completely solid state. The unit shall transform 480 Volt or 208 Volt (as indicated on plans), 3 phase, 60 hertz input power into frequency and voltage controlled, 3 phase output power suitable to provide positive speed and torque control to the fan motor. The speed control shall be step-less throughout the speed range under variable torque load on a continuous basis. The adjustable frequency control shall be of a pulse width modulated type utilizing a full wave diode bridge rectifier; and shall have a power factor of 0.95 or better at all motor loads.

D. All AFD’s shall have the same customer interface, including a backlit LCD two-line digital display, and keypad, regardless of horsepower rating. The keypad is to be used for local control, for setting all parameters, and for stepping through the displays and menus. The keypad shall be removable, capable of remote mounting, and shall have its own non-volatile memory. The keypad shall allow for uploading and downloading of parameter settings as an aid for the start-up of multiple AFD’s. The keypad shall include Hand-Off-Auto membrane selections. When in “Hand”, the AFD will be started and the speed will be controlled from the up/down arrows. When in “Off”, the AFD will be stopped. When in “Auto”, the AFD will start via an external contact closure and the AFD speed will be controlled via an external speed reference.

E. The adjustable frequency inverter shall conduct no radio frequency interference (RFI) back to the input power line.

F. The AFD shall have an integral 5% impedance line reactor to reduce the harmonics to the power line and to add protection from AC line transients. The inverter/reactor shall be a single wiring point.

2.03 SELF PROTECTION

A. The following features for self-protection shall be included:

1. The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes. The minimum FLA rating shall meet or exceed the values in the NFPA 70 - Table 430-150 for 4-pole motors.

2. Limit the output current in under 50 microseconds due to phase to phase short circuits or severe overload conditions.

3. Protect the inverter due to non-momentary power or phase loss. The undervoltage trip shall activate automatically when the line voltage drops 15% below rated input voltage.

4. Protect the inverter due to voltage levels in excess of its rating. The overvoltage trip shall activate automatically when the DC bus in the controller exceeds 1000 VDC.

5. Protect the inverter from elevated temperatures in excess of its rating. An indicating light that begins flashing within 10 degrees C of the trip shall be provided to alert the operator to the increasing temperature condition. When the over temperature trip point is reached, this light shall be continuously illuminated.

6. The inverter shall be equipped such that a trip condition resulting from overcurrent, undervoltage, overvoltage or overtemperature shall be automatically reset, and the inverter shall be automatically reset, and the inverter shall automatically restart upon removal, or correction of the faulty condition.
7. Status lights for indication of conditions described above shall be provided. A SPDT contact for remote indication shall be provided. Additionally, status lights to show power on, zero speed, and drive enabled shall be provided. All status lights shall be self-contained in the front panel of the unit and shall be duplicated for ease of troubleshooting on the inside of the unit.
8. Current and voltage signals shall be isolated from logic circuitry.
9. Drive logic shall be microprocessor based.
10. In the event of a sustained power loss, the control shall shut down safely without component failure. Upon return of power, the system shall automatically return to normal operation if the start is in the “On” condition.
11. In the event of a momentary power loss, the control shall be shut down safely without component failure. Upon return of power, the system shall automatically return to normal operation (if the start is in the “On” position) being able to restart into a rotating motor regaining positive speed control without shutdown or component failure.
12. In the event of a phase to phase short circuit, the control shall shut down safely without component failure.
13. In the event that an input power contactor is opened or closed while the control is activated, no damage shall result.
14. To facilitate startup and troubleshooting, the control shall operate without a motor or any other equipment connected to the inverter output.

2.04 ELECTRICAL CONSTANT SPEED BYPASS

A. Provide all components and circuitry necessary to provide manual full 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. Fast-acting semi-conductor with a fuse block shall be provided to isolate the drive for service. Bypass designs that have no such fuses must have a lockable disconnect that isolates the drive while running in bypass mode. The Contractor device shall be NEC approved. A common start/stop signal shall be used for both the variable frequency drive mode and bypass mode. Manual bypass shall contain the following:

1. Two contactors mechanically interlocked via a three position through the door selector switch or keypad to provide the following controls:
   a. “Inverter” mode connects the motor to the output of the inverter.
   b. “Bypass” mode connects the motor to the input since wave power. Transfer must occur with input disconnect open. Motor is protected via electronic overload.
   c. “Off” mode disconnects motor from all input power.
   d. A molded case circuit breaker with door interlocked handle (lock out type) that interrupts input power to both the bypass circuitry and the drive.
   e. Customer Interlock Terminal Strip - provide a separate terminal strip for connection of freeze, fire, smoke contacts, and external start command. All external safety interlocks shall remain fully functional whether the system is Hand, Auto, or Bypass mode. The remote start/stop contact shall operate in AFD and bypass modes.
   f. An electronic overload selectable for class 20 or 30 shall provide protection of the motor in Bypass mode.

2. The following indicating lights (LED type) shall be provided. A test mode or push to test feature shall be provided.
   a. Power on
   b. External fault
   c. Drive mode selected
   d. Bypass mode selected
   e. Drive running
   f. Bypass running
   g. Drive fault
   h. Bypass fault
   i. Bypass-H-O-A mode
   j. Automatic transfer to bypass selected

3. The following relay (form C) outputs from the bypass shall be provided:
   a. System started
b. System running

c. Bypass override enabled

d. Drive fault

e. Bypass fault (motor overload or underload (broken belt))

f. Bypass H-O-A position

4. The AFD shall include a “run permissive circuit” that will provide a normally open contact any time a run command is provided (local or remote start command in AFD or bypass mode). The AFD system (AFD or bypass) shall not operate the motor until it receives a dry contact closure from a damper or valve end-switch). When the AFD systems safety interlock (fire detector, freezestat, high static pressure switch, etc.) opens, the motor shall coast to a stop and the run permissive contact shall open, closing the damper or valve.

5. There shall be an internal switch to select manual or automatic bypass.

6. There shall be an adjustable current sensing circuit for the bypass to provide loss of load indication when in the bypass mode.

7. The bypass mode must include an undervoltage and phase loss relay to protect the motor from single phase power and undervoltage conditions.

a. Bypass shall be UL listed.

b. Bypass shall carry a UL 508 label.

2.05 FEATURES AND SPECIFICATIONS

A. Output frequency shall neither vary with load nor with any input frequency variations. Output frequency shall not vary within +/-10% input voltage changes. Output frequency shall not vary with temperature changes within the ambient specification.

B. No auxiliary equipment shall be required. The output frequency shall be adjusted in proportion to 4-20 mA signal.

C. A 0 to 10 Volt DC signal shall be provided for remote indication. This 0 to 10 Volt DC signal shall vary in direct proportion to the controller speed.

D. The controller shall be started or stopped by a contact closure or through serial communications.

E. A single pole, double throw contact shall be provided for remote indication. Contact will change state when any trip condition has occurred. (contact rated for 12-250 VAC-2 AMPS).

F. A second single pole, double throw contact shall be provided for remote indication. Contact will state when the VFD receives a run command (contact rated for 12-250 VAC-24 AMPS).

G. PID Setpoint controller shall be standard in the drive, allowing a pressure or flow signal to be connected to the AFD, using the microprocessor in the AFD for the closed loop control. The AFD shall have 250 ma of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by others. The PID setpoint shall be adjustable from the AFD keypad, analog inputs, or over the communications bus.

H. Unit to operate from a 4 to 20 mA input signal and shall have hand-off-auto switch and door mounted potentiometer controls for manual speed selection.

I. Acceleration and deceleration times shall be adjustable from 30 to 300 seconds.

J. The drive shall have the ability to invert the speed signal input, as well as having offset and gain controls for speed signal conditioning.

K. Minimum and maximum speeds shall be adjustable in automatic and manual modes.

L. Hazard inputs shall be provided, capable of up to two inputs (fire, freeze). These shall each be capable of safely shutting down the inverter and illuminating a front panel hazard light depicting that a hazard condition turned the inverter off.

M. The inverter shall be a starter, containing a door interlocked input disconnect switch and manual reset motor electronic overloads, with accessible reset on front door, when a bypass is not specified.

N. Solid state ground fault interrupt circuit.

O. The LED display shall monitor and display four parameters on a single display (i.e. frequency command, output frequency, output current, and torque).
P. A N.O. auxiliary run-time contact shall be provided for control signaling to auxiliary equipment. Contact shall close when the pump is brought on line and open when the pump is taken off line. Contact shall be rated 20 amps at 120 volts.

Q. Inverter shall be UL listed.

R. Certified factory start-up shall be provided for each drive by a factory authorized service center. A certified start-up form shall be filled out for each drive with a copy provided to the Owner, and a copy kept on file at the manufacturer.

S. Factory trained application engineering and service personnel that are thoroughly familiar with the AFD products offered shall be locally available at both the specifying and installation locations. A 24/365 technical support line shall be available on a toll-free line.

T. A computer based training CD or 8-hour professionally generated video (VCR format) shall be provided to the Owner at the time of Substantial Completion. The training shall include installation, programming and operation of the AFD, bypass and serial communication.

U. Provide a motor end surge control voltage suppressive filter if the VFD manufacturer cannot limit their voltage surges to under 1000 volt at 100 feet.

V. Provide a motor acoustic noise reduction filter capable of approximately 12 dBA attenuation, if the VFD raises the dBa level above 3 dBa at a distance of 3 feet from the motor.

W. Provide each unit with a 3% reactor which is mounted on both the positive and negative DC bus. The reactor shall be a single wiring point and mounted internally to the drive.

X. Adjustable frequency inverters shall have native BACnet protocol for integration with EMCS. If the inverter does not have native BACnet protocol, a BACnet interface card shall be provided.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units in accordance with manufacturer’s published installation instructions. Variable frequency speed control shall be located so that wiring to motor does not exceed 100 feet.

END OF SECTION
SECTION 23 05 29

HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT - HVAC

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
   A. Pipe, and equipment hangers, supports and associated anchors.
   B. Sleeves and seals.
   C. Flashing and sealing equipment and pipe stacks.

1.03 RELATED WORK
   A. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
   B. Section 23 07 16 - HVAC Equipment Insulation
   C. Section 23 07 19 - HVAC Piping Insulation
   D. Section 23 21 13 - Above Ground Hydronic Piping
   E. Section 23 21 16 - Underground Hydronic Piping

1.04 REFERENCES
   A. ASME B31.1 - Power Piping.
   B. ASME B31.9 - Building Services Piping.

1.05 QUALITY ASSURANCE
   B. Hangers and Supports for HVAC Piping: In conformance with MSS SP-58.

1.06 SUBMITTALS
   A. Submit shop drawings and product data under provisions of Division One.
   B. Indicate hanger and support framing and attachment methods.

PART 2 - PRODUCTS

2.01 PIPE HANGERS AND SUPPORTS
   A. Hangers for Pipes Sizes 1/2 to 1-1/2 Inch: Malleable iron, adjustable swivel, split ring.
   B. Hangers for Pipes Sizes 2 to 4 Inch: Carbon steel, adjustable clevis.
   C. Hangers for Pipes Sizes 6 Inches and Over: Adjustable steel yoke, cast iron roller, double hanger.
   D. Multiple or Trapeze Hangers: Steel channels with welded spacers, pre-formed manufactured saddles and hanger rods; cast iron roller and stand for pipe sizes 6 inches and over.
   E. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
   F. Wall Support for Pipe Sizes 4 Inches and over: adjustable steel yoke and cast iron roller.
   G. Vertical Support: Steel riser clamp.
   H. Floor Support for Pipe Sizes to 4 Inches: Cast iron adjustable pipe saddle, locknut nipple, floor flange, and concrete pier or steel support.
   I. Floor Support for Pipe Sizes 6 Inches and Over: Adjustable cast iron roller and stand, steel screws, and concrete pier or steel support.
J. Roof Pipe Supports and Hangers: Galvanized Steel Channel System as manufactured by Portable Pipe Hangers, Inc. or approved equal.
   1. For pipes 2-1/2” and smaller - Type PP10 with roller
   2. For pipes 3” through 8” - Type PS
   3. For multiple pipes - Type PSE - Custom
L. Shields for Vertical Copper Pipe Risers: Sheet lead.
M. Pipe Rough-In Supports in Walls/Chases: Provide preformed plastic pipe supports, Sioux Chief “Pipe Titan” or equal.

2.02 HANGER RODS
A. Galvanized Hanger Rods: Threaded both ends, threaded one end, or continuous threaded.

2.03 INSERTS
A. Inserts: Malleable iron case with galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.04 FLASHING
A. Metal Flashing: 20 gage galvanized steel.
B. Lead Flashing: 4 lb. /sq. ft. sheet lead for waterproofing; 1 lb. /sq. ft. sheet lead for soundproofing.
C. Caps: Steel, 20 gage minimum; 16 gage at fire resistant elements.
D. Coordinate with roofing contractor/Architect for type of flashing on metal roofs.

2.05 EQUIPMENT CURBS
A. Fabricate curbs of hot dipped galvanized steel.
B. For metal roof construction, roof curbs shall be made of aluminum or stainless steel. Coordinate with Architectural Drawings and details.

2.06 SLEEVES
A. Sleeves for Pipes through Non-fire Rated Floors: Form with 18 gage galvanized steel, tack welded to form a uniform sleeve.
B. Sleeves for Pipes through Non-fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Form with steel pipe, Schedule 40.
C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Walls, and Fireproofing: Prefabricated fire rated steel sleeves including seals, UL listed.
D. Sleeves for Round Ductwork: Form with galvanized steel.
E. Sleeves for Rectangular Ductwork: Form with galvanized steel.
F. Fire Stopping Insulation: Glass fiber type, non-combustible, UL listed.
G. Caulk: Paintable 25-year acrylic sealant.
H. Pipe Alignment Guides: Factory fabricated, of cast semi-steel or heavy fabricated steel, consisting of bolted, two-section outer cylinder and base with two-section guiding spider that bolts tightly to pipe. Length of guides shall be as recommended by manufacturer to allow indicated travel.

2.07 FABRICATION
A. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
B. Design hangers without disengagement of supported pipe.
C. Design roof supports without roof penetrations, flashing or damage to the roofing material.

2.08 FINISH
A. Prime coat exposed steel hangers and supports. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.
PART 3 - EXECUTION

3.01 INSERTS
A. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams. Coordinate with Structural Engineer for placement of inserts.
B. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
C. Where concrete slabs form finished ceiling, provide inserts to be flush with slab surface.
D. Where inserts are omitted, drill through concrete slab from below and provide thru-bolt with recessed square steel plate and nut recessed into and grouted flush with slab. Verify with Structural Engineer prior to start of work.

3.02 PIPE HANGERS AND SUPPORTS
A. Support horizontal piping as follows:

<table>
<thead>
<tr>
<th>PIPE SIZE</th>
<th>MAX. HANGER SPACING</th>
<th>HANGER DIAMETER</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Steel Pipe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 to 1-1/4 inch</td>
<td>7'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>1-1/2 to 3 inch</td>
<td>10'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>4 to 6 inch</td>
<td>10'-0&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>8 to 10 inch</td>
<td>10'-0&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>12 to 14 inch</td>
<td>10'-0&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>15 inch and over</td>
<td>10'-0&quot;</td>
<td>7/8&quot;</td>
</tr>
<tr>
<td>(Copper Pipe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1/2 to 1-1/4 inch</td>
<td>5'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>1-1/2 to 2-1/2 inch</td>
<td>8'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>3 to 4 inch</td>
<td>10'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>6 to 8 inch</td>
<td>10'-0&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>(Cast Iron Pipe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 to 3 inch</td>
<td>5'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>4 to 6 inch</td>
<td>10'-0&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>8 to 10 inch</td>
<td>10'-0&quot;</td>
<td>5/8&quot;</td>
</tr>
<tr>
<td>12 to 14 inch</td>
<td>10'-0&quot;</td>
<td>3/4&quot;</td>
</tr>
<tr>
<td>15 inch and over</td>
<td>10'-0&quot;</td>
<td>7/8&quot;</td>
</tr>
<tr>
<td>(PVC Pipe)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-1/2 to 4 inch</td>
<td>4'-0&quot;</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td>6 to 8 inch</td>
<td>4'-0&quot;</td>
<td>1/2&quot;</td>
</tr>
<tr>
<td>10 inch and over</td>
<td>4'-0&quot;</td>
<td>5/8&quot;</td>
</tr>
</tbody>
</table>

B. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
C. Place a hanger within 12 inches of each horizontal elbow, and at the vertical to horizontal transition.
D. Use hangers with 1-1/2 inch minimum vertical adjustment.
E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
H. Support riser piping independently of connected horizontal piping.
I. Install hangers with nut at base and above hanger; tighten upper nut to hanger after final installation adjustments.
J. Portable pipe hanger systems shall be installed per manufacturer's instructions.
K. Distances between supports are maximum distance. Supports shall be provided to carry the pipe/equipment load.

3.03 INSULATED PIPING

A. Clamps: Attach galvanized clamps, including spacers (if any), to piping with clamps projecting through insulation; do not exceed pipe stresses allowed by ASME B31.9.

B. Saddles: Install galvanized protection saddles MSS Type 39 where insulation without vapor barrier is indicated. Fill interior voids with segments of insulation that match adjoining pipe insulation. Secure the full contact area of the saddle to the pipe insulation with 1/8” thick coat of mastic.

C. Shields: Install protective shields MSS Type 40 on cold and chilled water piping that has vapor barrier. Secure the full contact area of the shield to the pipe insulation with 1/8” thick coat of mastic.

D. Shields shall span an arc of 180 degrees and shall have dimensions in inches not less than the following:

<table>
<thead>
<tr>
<th>Nominal Pipe Size</th>
<th>Shield Length</th>
<th>GaugeThickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/4 through 3-1/2 inch</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>4 inch</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>5 through 6 inch</td>
<td>18</td>
<td>16</td>
</tr>
<tr>
<td>8 through 14 inch</td>
<td>24</td>
<td>14</td>
</tr>
<tr>
<td>16 through 24 inch</td>
<td>24</td>
<td>12</td>
</tr>
</tbody>
</table>

E. Piping 2” and larger: provide galvanized sheet metal shields with calcium silicate insulation at hangers/supports.

F. Insert material shall be at least as long as the protective shield.

G. Thermal Hanger Shields: Install where indicated, with insulation of same thickness as piping.

3.04 EQUIPMENT BASES AND SUPPORTS

A. Provide equipment bases of concrete.

B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.

C. Construct support of steel members. Brace and fasten with flanges bolted to structure.

D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.05 FLASHING

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

B. Provide curbs for mechanical roof installations 8 inches minimum high above roofing surface. Contact Architect for all flashing details and roof construction. Seal penetrations watertight.

3.06 SLEEVES

A. Set sleeves in position in formwork. Provide reinforcing around sleeves.

B. Extend sleeves through floors minimum one inch above finished floor level. Caulk sleeves full depth with fire rated thermafiber and 3M caulking and provide floor plate.

C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with UL listed fire stopping insulation and caulk seal air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.

D. Fire protection sleeves may be flush with floor of stairways.

END OF SECTION
SECTION 23 05 48
VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL
1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
   A. Vibration and sound control products.

1.03 QUALITY ASSURANCE
   A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of vibration control products of type, size, and capacity required, whose products have been in satisfactory use in similar service for not less than 5 years.
   B. Vibration and sound control products shall conform to ASHRAE criteria for average noise criteria curves for all equipment at full load conditions.
   C. Unless otherwise indicated, sound and vibration control products shall be provided by a single manufacturer.

1.04 SUBMITTALS
   A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
   B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

PART 2 - PRODUCTS
2.01 ACCEPTABLE MANUFACTURERS
   A. Amber/Booth Company, Inc.
   B. Mason Industries, Inc.
   C. Kinetics Noise Control, Inc.
   D. Vibration Eliminator Co., Inc.

2.02 GENERAL
   A. Provide vibration isolation supports for equipment, piping and ductwork, to prevent transmission of vibration and noise to the building structure that may cause discomfort to the occupants.
   B. Model numbers of Amber/Booth products are included for identification. Products of the additional manufacturers will be acceptable provided they comply with all the requirements of this specification.

2.03 FLOOR MOUNTED AIR HANDLING UNITS
   A. Provide Amber/Booth CAL-2 aluminum housed isolators sized for 2” static deflection. Cast iron or steel housings may be used provided they are hot-dip galvanized after fabrication.
   B. If floor mounted air handling units are furnished with internal vibration isolation option, provide 2” thick Amber/Booth NRC ribbed neoprene pads to address high frequency breakout and afford additional unit elevation for condensate drains. Ribbed neoprene pads shall be located in accordance with the air handling unit manufacturer’s recommendations.

2.04 BASE MOUNTED PUMPS
   A. Provide Amber/Booth SP-NR style E flexplate pad isolators consisting of two layers of 3/8” thick alternate ribbed neoprene pad bonded to a 16 gage galvanized steel separator plate.
   B. Pads shall be sized for approximately 40 psi loading and 1/8” deflection.
   C. Provide Amber/Booth CPF, 8” concrete inertia base. Base shall be welded steel construction with concrete in-fill supplied by the contractor on site and shall incorporate...
standard rebar reinforcement, spaced a maximum of 12” on center. Provide Amber/Booth AWH, floor mounted spring isolators sized for 1” static deflection.

D. Provide inertia bases for all base mounted pump applications in which the pumps are to be installed on any floor level other than the ground floor or grade level. Inertia bases shall also be provided for base mounted pump applications in which the associated mechanical room where they are housed is in a noise sensitive location, regardless of floor level.

2.05 PIPING
A. Provide spring and rubber-in-shear hangers, Amber/Booth HRS in mechanical equipment rooms, for a minimum distance of 50 feet from isolated equipment for all chilled water and hot water piping 1-1/2” diameter and larger. Springs shall be sized for 1” deflection.

B. Floor supported piping is required to be isolated with Amber/Booth AW-1 open springs sized for 1” deflection.

C. All condenser water piping shall be supported with Amber/Booth AW-1 with 1” deflection for floor or roof mounted piping and Amber/Booth HRS isolators with 1” deflectors for suspended piping.

D. Furnish line size flexible connectors at supply and return of pumps, Amber/Booth style 2800 single sphere EPDM construction, connector shall include 150 lb. cadmium plated carbon steel floating flanges.

2.06 CORROSION PROTECTION
A. All vibration isolators shall be designed and treated for resistance to corrosion.

B. Steel components: PVC coated or phosphate coated and painted with industrial grade enamel. Nuts, bolts, and washers: zinc-electroplated.

PART 3 - EXECUTION

3.01 INSTALLATION
A. All equipment shall be installed in accordance with the manufacturer’s recommendations and printed installation instructions.

B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.

C. If internal isolation option is used on air handling units, the mechanical contractor shall verify proper adjustment and operation of isolators prior to start-up. All shipping brackets and temporary restraint devices shall be removed.

D. The vibration isolation supplier shall certify in writing that he has inspected the installation and that all external isolation materials and devices are installed correctly and functioning properly.

END OF SECTION
SECTION 23 05 53

IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL
1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 SCOPE
   A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.
   B. Refer to Architectural Sections for additional requirements.

PART 2 - PRODUCTS
2.01 VALVE AND PIPE IDENTIFICATION
   A. Valves:
      1. All valves shall be identified with a 1-1/2” diameter brass disc wired onto the handle. The disc shall be stamped with 1/2” high depressed black filled identifying numbers. These numbers shall be numerically sequenced for all valves on the job.
      2. The number and description indicating make, size, model number and service of each valve shall be listed in proper operational sequence, properly typewritten. Three copies to be turned over to Owner at completion.
      3. Tags shall be fastened with approved meter seal and 4 ply 0.018 smooth copper wire. Tags and fastenings shall be manufactured by the Seton Name Plate Company or approved equal.
      4. All valves shall be numbered serially with all valves of any one system and/or trade grouped together.
   B. Pipe Marking:
      1. All interior visible piping located in accessible spaces such as above accessible ceilings, equipment rooms, attic space, under floor spaces, etc., shall be identified with all temperature pipe markers as manufactured by W.H. Brady Company, 431 West Rock Ave., New Haven, Connecticut, or approved equal.
      2. All exterior visible piping shall be identified with UV and acid resistant outdoor grade acrylic plastic markers as manufactured by Set Mark distributed by Seton (Name plate Company Factory location 20 Thompson Road, Branford, Connecticut) or approved equal.
      3. Generally, markers shall be located on each side of each and every partition, on each side of every tee, on each side of every valve and/or valve group, on each side of every piece of equipment, and, for straight runs, at equally spaced intervals not to exceed 75 feet. In congested area, marks shall be placed on each pipe at the points where it enters and leaves the area and at the point of connection of each piece of equipment and automatic control valve. All markers shall have directional arrows.
      4. Markers shall be installed after final painting of all piping and equipment and in such a manner that they are visible from the normal maintenance position. Manufacturer's installation instructions shall be closely followed.
      5. Markers shall be colored as indicated below per ANSI/OSHA Standards:

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>COLOR</th>
<th>LEGEND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot Water</td>
<td>Reddish Orange</td>
<td>Hot Water Supply; Hot Water Return</td>
</tr>
<tr>
<td>Condenser Water</td>
<td>Green</td>
<td>Condenser Water Supply; Condenser Water Return</td>
</tr>
</tbody>
</table>

C. Pipe Painting:
   1. All piping exposed to view shall be painted as indicated or as directed by the Architect in the field. Confirm all color selections with Architect prior to installation.
2. All piping located in mechanical rooms and exterior piping shall be painted as indicated below:

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>COLOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condenser Water Supply and Return</td>
<td>Light Green</td>
</tr>
<tr>
<td>Heating Hot Water Supply and Return</td>
<td>Reddish Orange</td>
</tr>
</tbody>
</table>

2.02 EQUIPMENT IDENTIFICATION

A. Mechanical equipment shall be identified by means of nameplates permanently attached to the equipment. Nameplates shall be engraved laminated plastic or etched metal. Submittals shall include dimensions and lettering format for approval. Attachment shall be with escutcheon pins, self-tapping screws, or machine screws.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All labeling equipment shall be installed as per manufacturer’s printed installation instructions.

B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractors price shall include all items required as per manufacturer’s requirements.

C. All piping shall be cleaned of rust, dirt, oil and all other contaminants prior to painting. Refer to Division 9 for Architect’s required paint system(s).

END OF SECTION
SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 RELATED DOCUMENTS

A. Approved submittal date on equipment installed, to accomplish the test procedures, outlined under paragraph 3.01 of this Section, will be provided by the Contractor.

1.03 DESCRIPTION

A. The TAB of the air conditioning systems shall be performed by an impartial technical firm hired by the Owner whose operations are limited only to the field of professional TAB. The TAB work will be done under the direct supervision of a qualified engineer employed by the TAB firm.

B. The TAB firm will be responsible for inspecting, adjusting, balancing, and logging the date on the performance of fans, dampers in the duct system, and air distribution devices. The Contractor and the various Subcontractors of the equipment installed shall cooperate with the TAB firm to furnish necessary data on the design and proper applications of the system components and provide labor and material required to eliminate deficiencies or malperformance.

1.04 QUALITY ASSURANCE

A. QUALIFICATIONS OF CONTRACTOR PERSONNEL: Submit evidence to show that the personnel who shall be in charge of correcting deficiencies for balancing the systems are qualified. The Owner and Engineer reserve the right to require that the originally approved personnel be replaced with other qualified personnel if, in the Owner and Engineer's opinion, the original personnel are not qualified to properly place the system in condition for balancing.

B. QUALIFICATIONS OF TAB FIRM PERSONNEL:

1. A minimum of one registered Professional Engineer licensed in the State, is required to be in permanent employment of the firm.

2. Personnel used on the jobsite shall be either Professional Engineers or technicians, who shall have been permanent, full time employees of the firm for a minimum of six months prior to the start of Work for that specified project.

3. Evidence shall be submitted to show that the personnel who actually balance the systems are qualified. Evidence showing that the personnel have passed the tests required by the Associated Air Balance Council (AABC) shall be required.

C. CALIBRATION LIST: Submit to the Engineer for approval, a list of the gauges, thermometers, velometer, and other balancing devices to be used in balancing the system. Submit evidence to show that the balancing devices are properly calibrated before proceeding with system balancing.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 SERVICES OF THE CONTRACTOR

A. The Drawings and Specifications have indicated valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions. Install these devices in a manner that leaves them accessible, and provide access as requested by the TAB firm.

B. Have systems complete and in operational readiness prior to notifying the TAB firm that the project is ready for their services, and certify in writing to the Architect and Owner that such a condition exists.
C. As a part of the Work of this Section, make changes in the sheaves, belts, and dampers or the addition of dampers required for correct balance of the new work as required by the TAB firm, at no additional cost to the Owner.

D. Fully examine the existing system to be balanced, to determine whether or not sufficient volume dampers, balancing valves, thermometers, gauges, pressure and temperature taps, means of reading static pressure and total pressure in duct systems, means of determining water flow, and other means of taking data needed for proper water and air balancing are existing. Submit to the Engineer in writing a listing of omitted items considered necessary to balance existing systems. Submit the list and proposal as a cost add item.

E. Verify that fresh air louvers are free of blockage, coils are clean and fresh air ducts to each air handling unit have individually adjustable volume regulating dampers.

F. Provide, correct, repair, or replace deficient items or conditions found during the testing, adjusting, and balancing period.

G. In order that systems may be properly tested, balanced, and adjusted as specified, operate the systems at no expense to the Owner for the length of time necessary to properly verify their completion and readiness for TAB period.

H. Project construction schedules shall provide time to permit the successful completion of TAB services prior to Substantial Completion. Complete, operational readiness, prior to commencement of TAB services, shall include the following services of the Contractor:
   1. Construction status of building shall permit the closing of doors, windows, ceilings installed and penetrations complete, to obtain project operating conditions.
   2. AIR DISTRIBUTION SYSTEMS:
      a. Verify installation for conformity to design. Supply, return, and exhaust ducts terminated and pressure tested for leakage as specified.
      b. Volume and fire dampers properly located and functional. Dampers serving requirements of minimum and maximum outside air, return and relief shall provide tight closure and full opening, smooth and free operation.
      c. Supply, return, exhaust and transfer grilles, registers and diffusers shall be installed.
      d. Air handling systems, units and associated apparatus, such as heating and cooling coils, filter sections, access doors, etc., shall be blanked and sealed to eliminate excessive bypass or leakage of air.
      e. Fans (supply and exhaust) operating and verified for freedom from vibrations, proper fan rotation and belt tension; overload heater elements shall be of proper size and rating; record motor amperage and voltage and verify that these functions do not exceed nameplate ratings.
      f. Furnish or revise fan drives or motors as necessary to attain the specified air volumes.

3. WATER CIRCULATING SYSTEMS:
   a. Position valves pertinent to system design and require operation to permit full flow of water through system components. Operate hydronic systems under full flow conditions until circulating water is clean. Remove and clean strainers as required during this cycle of operation.
   b. For retrofit projects, record each existing pump motor amperage and voltage. Readings shall not exceed nameplate rating.
   c. Verify, on new equipment, electrical starter overload heater elements to be of proper size and rating.
   d. Ensure that water circulating systems shall be full of water and free of air; expansion tanks set for proper water level, and air vents installed at high points of systems and operating freely. Advise Engineer of deficiencies.
   e. Check and set operating temperatures of heat exchangers to design requirements.
   f. The various existing water circulating systems shall be cleaned, filled, purged of air, and put into operation before hydronic balancing.

4. AUTOMATIC CONTROLS:
   a. Verify that control components are installed in accordance with project documents and functional, electrical interlocks, damper sequences, air and water resets, fire and freeze stats.
b. Controlling instruments shall be functional and set for design operating conditions. Factory precalibration of room thermostats and pneumatic equipment will not be acceptable.

c. The temperature regulation shall be adjusted for proper relationship between the controlling instruments and calibrated by the TAB Contractor. Advise Engineer of deficiencies or malfunctions.

I. Contractor shall repair any insulation removed from piping system by TAB Contractor during water balancing.

### 3.02 SERVICES OF THE TAB FIRM

A. The TAB firm will act as liaison between the Owner, Engineer, and the Contractor and inspect the installation of mechanical piping system, sheet metal work, temperature controls and other component parts of the heating, air conditioning and ventilating systems being retrofitted, repaired, or added under this Contract. The reinspection of the Work will cover that part related to proper arrangement and adequate provision for the testing and balancing and will be done when the Work is 80 percent complete.

B. Upon completion of the installation and start-up of the mechanical equipment, to check, adjust, and balance system components to obtain optimum conditions in each conditioned space in the building. Prepare and submit to the Engineer complete reports on the balance and operations of the systems.

C. Measurements and recorded readings of air, water, and electricity that appear in the reports will be done by the permanently employed technicians or engineers of the TAB firm.

D. Make an inspection in the building during the opposite season from that in which the initial adjustments were made. At the time, make necessary modifications to the initial adjustments required to produce optimum operation of system components to affect the proper conditions as indicated on the Drawings. At time of opposite season check-out, the Owner's representative will be notified before readings or adjustments are made.

E. In fan systems, the air quantities indicated on the Drawings may be varied as required to secure a maximum temperature variation of two degrees within each separately controlled space, but the total air quantity indicated for each zone must be obtained. It shall be the obligation of the Contractor to furnish or revise fan drive and motors if necessary, without cost to the Owner, to attain the specified air volumes.

F. Contractor shall utilize ultrasonic flow meter to balance water flow of existing water system if the original pressure drop data is not available. Contractor shall remove insulation as necessary to use flow meter.

G. Participate in the commissioning process, which shall include but not be limited to attending commissioning meetings, coordinating work with and completing checklists as required by the commissioning team.

### 3.03 PROFESSIONAL REPORT

A. Before the final acceptance of the report is made, the TAB firm will furnish the Engineer the following data to be approved by the Owner and Engineer:

1. Summary of main supply, return and exhaust duct pitot tube traverses and fan settings indicating minimum value required to achieve specified air volumes.

2. A listing of the measured air quantities at each outlet corresponding to the temperature tabulation as developed by the Engineer and TAB firm.

3. Air quantities at each return and exhaust air handling device.

4. Static pressure readings entering and leaving each supply fan, exhaust fan, filter, coil, balancing dampers and other components of the systems. Including the retrofit Work. These readings will be related to performance curves in terms of the CFM handled if available.

5. Motor current readings at each equipment motor on load side of capacitors. The voltages at the time of the reading shall be listed.

6. The final report shall certify test methods and instrumentation used, final velocity reading obtained, temperatures, pressure drops, RPM of equipment, amperage of motors, air balancing problems encountered, recommendations and uncompleted punch list items. The test results will be recorded on standard forms.
7. A summary of actual operating conditions shall be included with each system outlining normal and ventilation cycles of operation. The final report will act as a reference of actual operating conditions for the Owner’s operating personnel.

3.04 BALANCING AIR CONDITIONING SYSTEM

A. GENERAL:
1. Place all equipment into full operation, and continue operating during each working day of balancing and testing. If the air conditioning system is balanced during Off-Peak cooling season Contractor shall return to rebalance air side system as required to put system in proper balance at that season.
2. The Contractor shall submit detailed balancing and recording forms for approval. After approval by the Engineer, prepare complete set of forms for recording test data on each system. All Work shall be done under the supervision of a Registered Professional Engineer. All instruments used shall be accurately calibrated to within 1% of scale and maintained in good working order.
3. Upon completion of the balancing and testing, the TAB Contractor shall compile the test data in report forms, and forward five copies to the Engineer for evaluation.
4. The final report shall contain logged results of all tests, including such data as:
   a. Tabulation of air volume at each outlet.
   b. Outside dry bulb and wet bulb temperature.
   c. Inside dry bulb and wet bulb temperatures in each conditioned space room or area.
   d. Actual fan capacities and static pressures. Motor current and voltage readings at each fan.

B. AIR SYSTEMS: Perform the following operations as applicable to balance and test systems:
1. Check fan rotation.
2. Check filters (balancing shall be done with clean filters).
3. Test and adjust blower rpm to design requirements.
4. Test and record motor full load amperes.
5. Test and record system static pressures, suction and discharge.
6. Test and adjust system for design cfm, return air and outside air (±2%). Change-out fan sheaves as required to balance system.
7. Test and record entering air temperatures, db and wb.
8. Test and record leaving air temperatures, db and wb.
9. Adjust all zones to design cfm (±2%).
10. Test and adjust each diffuser, grille, and register to within 5% of design.

C. AIR DUCT LEAKAGE: (From SMACNA Duct Standards latest edition) Test all ductwork (designed to handle over 1000 CFM) as follows:
1. Test apparatus
   a. The test apparatus shall consist of:
   b. A source of high pressure air - a portable rotary blower or a tank type vacuum cleaner.
   c. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
2. Test Procedures
   a. Test for audible leaks as follows:
      1) Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
      2) Start the blower with its control damper closed.
      3) Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
      4) Survey all joints for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
   b. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
1) Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
2) Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
3) Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the summation of the leakage for all sections shall not exceed the total allowable leakage.
4) Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which must be corrected.

D. Automatic temperature controls shall be calibrated; and all thermostats and dampers adjusted so that the control system is in proper operating condition, subject to the approval of the Engineer/Owner.

E. The TAB Contractor shall report to Engineer all air distribution devices or other equipment that operate noisily so that corrective measures may be implemented by the Contractor at no additional cost to the Owner or Architect/Engineer.

END OF SECTION
SECTION 23 07 13

DUCT INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED

A. Ductwork system insulation.

1.03 RELATED SECTIONS

A. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC

B. Section 23 05 53 - Identification for HVAC Piping and Equipment

C. Section 23 31 13 - Metal Ductwork

1.04 REFERENCE STANDARDS


L. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

M. UL 2824 - GREENGUARD Certification Program Method for Measuring Microbial Resistance From Various Sources Using Static Environmental Chambers.


1.05 QUALITY ASSURANCE

A. Installer’s Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

B. Flame/Smoke Ratings: Provide composite mechanical insulation (insulation, jackets, coverings, sealers, mastics and adhesives) that is UL Classified per UL 723 or with flame-spread index of 25 or less, and smoke-developed index of 50 or less, as tested by ASTM E84.

1. Exception: Outdoor mechanical insulation may have flame spread index of 75 and smoke developed index of 150.

C. Duct and plenum insulation shall comply with minimum R-value requirements of ICC (IECC) and ASHRAE Std 90.1 I-P.
D. Adhesive and other material shall comply with NFPA 90A and NFPA 90B.

1.06 WARRANTY
A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective, or nonconforming materials and workmanship.
B. Defects shall include, but not be limited to, the following:
   1. Mildewing.
   2. Peeling, cracking, and blistering.
   3. Condensation on exterior surfaces.

1.07 SUBMITTALS
A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.

1.08 DELIVERY, STORAGE AND HANDLING
A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer’s stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

PART 2 - PRODUCTS
2.01 GENERAL DESCRIPTION
A. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and approved before any insulation is installed.
B. A sample quantity of each type of insulation and each type of application shall be installed and approval secured prior to proceeding with the main body of the Work.

2.02 ACCEPTABLE MANUFACTURERS
A. Glass mineral wool materials shall be as manufactured by Knauf Insulation, Certain-Teed, Johns-Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer. All glass mineral wool insulation shall be UL GREENGUARD Gold certified.
B. Adhesives shall be as manufactured by Minnesota Mining, Arabol, Benjamin-Foster, Armstrong or Insulmastic, Inc., and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified herein, subject to review by the Engineer.
C. Ceramic fiber materials shall be as manufactured by Primer Refractories, A.P. Green Refractories or approved equal.

PART 3 - EXECUTION
3.01 GENERAL
A. All insulation shall be installed in accordance with the manufacturer’s recommendations and printed installation instructions.
B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.
C. Duct insulation shall be installed per SMACNA (DCS).

3.02 EXTERNAL DUCT INSULATION
A. Fasten all longitudinal and circumferential laps with outward clinching staples 3” on center. On rectangular ducts over 24” wide apply as above and hold insulation in place on bottom side with mechanical pins and clips on 12” centers.
B. Seal all joints, fastener penetrations and other breaks in vapor barrier with 3-inch wide strips of white glass fabric embedded between two coats of vapor barrier mastic, Childers
3.03 **DUCT LINER**

A. Duct liner shall be kept clean and dry during transportation, storage, installation, and throughout the construction process care should be taken to protect the liner from exposure to the elements or damage from mechanical abuse.

B. All portions of duct designed to receive duct liner shall be completely covered with liner as specified. The smooth, black, mat facing or acrylic-coated surfaces with flexible glass cloth reinforcement shall face the airstream. All duct liner shall be cut to assure tight, overlapped corner joints. The top pieces shall be supported by the sidepieces. Duct liner shall be installed following the guidelines in the NAIMA FGDLS.

C. The duct liner shall be tested according to erosion test method in ASTM C1071 and shall be guaranteed to withstand velocities in the duct system up to 6,000 fpm without surface erosion.

D. Duct liner shall be adhered to the sheet metal with full coverage of an approved adhesive that conforms to ASTM C916, and all exposed leading edges and transverse joints shall be coated with Permacote factory-applied or field-applied edge coating and shall be neatly butted without gaps. Shop or field cuts shall be liberally coated with Johns Manville SuperSeal® duct butter and Edge Treatment or approved adhesive.

E. Metal nosings shall be securely installed over transversely oriented liner edges facing the airstream at forward discharge and at any point where lined duct is preceded by unlined duct.

F. When velocity exceeds 4,000 fpm (20.3 m/sec), use metal nosing on every leading edge. Nosing may be formed on duct or be channel or zee attached by screws, rivets or welds.

G. The liner shall further be secured with Graham welding pins and washers on not more than 18 inch centers both vertical and horizontal surfaces, and the pins and washers shall be pointed up with adhesive.

H. Duct liner shall be Knauf Insulation Atmosphere Duct Liner with ECOSE Technology, Johns Manville Linacoustic RC duct liner with factory-applied edge coating and acrylic coating on the mat surface of airstream side or approved equal. The liner shall meet the Life Safety Standards as established by NFPA 90A and NFPA 90B, FHC 25/50 and Limited Combustibility and the air stream surface coating should contain an immobilized, EPA-registered, anti-microbial agent so it will not support microbial growth as tested in accordance with ASTM G21. The duct liner shall conform to the requirements of ASTM C1071, UL 2824, with an NRC not less than 0.70 as tested per ASTM C423 using a Type “A” mounting, and a thermal conductivity no higher than 0.24 BTU*in/(hr*ft²*°F) at 75°F mean temperature.

I. Line supply and return ductwork at connection of HVAC unit to a point of 15 feet upstream and downstream of the equipment and in return air boots. Attach with full cover coat of
cement, duct dimensions up to 16 inches; provide stick clips or screws and cap for
dimensions over 16 inches, spaced 16 inches o.c. maximum. Provide sheet metal liner
cap over all leading edges of internal insulation exposed to air stream.

J. Duct liner shall be provided as follows:
   1. 1" Thick, 1.5 PCF density minimum; minimum installed R-value of 4.2 when ducts are
       located in conditioned spaces.
   2. 1 ½" Thick with a minimum installed R-value of 6.0 when ducts are located in
       unconditioned spaces, such as ceiling plenum space.
   3. 2" Thick with a minimum installed R-value of 8.0 when ducts are located outdoors.

3.04 AIR DEVICE AND MISCELLANEOUS DUCT INSULATION
A. The backside of all supply air devices shall be insulated with taped and sealed 1-½ inch
   thick external duct wrap.
B. The contractor shall install an additional layer of 1-½ inch thick external glass mineral wool
   duct wrap on any portion of the supply air, return air, outside air, or exhaust air system that
   has condensation forming during any period of operation. The insulation shall be taped
   and vapor-sealed and located until all evidence of the condensation has been eliminated,
   at no additional cost to the Owner.

END OF SECTION
SECTION 23 07 16

HVAC EQUIPMENT INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 SCOPE

A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.

B. Work specified elsewhere.

1.  Basic materials and methods.

2.  Piping systems.

3.  Air distribution equipment.

1.03 REFERENCE STANDARDS


1.04 QUALITY ASSURANCE

A. Installer's Qualifications: Firm with at least 5 years successful installation experience on projects with mechanical insulations similar to that required for this project.

B. All insulation shall have composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) fire and smoke hazard as tested by Procedure ASTM E84 and UL 723 not exceeding: Flame Spread 25 and Smoke Developed 50.

C. All HVAC equipment insulation shall comply with minimum requirements of ICC (IECC) and ASHRAE Std 90.1 I-P.

D. Adhesives and other materials shall comply with NFPA 90A and NFPA 90B.

1.05 WARRANTY

A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials and workmanship.

B. Defects shall include, but not be limited to, the following:

1.  Mildewing.

2.  Peeling, cracking, and blistering.

3.  Condensation on exterior surfaces.

1.06 SUBMITTALS

A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.

B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, product variations, and accessories.
1.07 DELIVERY AND STORAGE
   A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer’s stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
   B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

PART 2 - PRODUCTS
2.01 EQUIPMENT INSULATION
   A. It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
   B. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and reviewed before any insulation is installed.
   C. A sample quantity of each type of insulation and each type application shall be installed and reviewed prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
   D. Glass mineral wool materials as manufactured by Knauf Insulation, Owens/Corning, Certain-Teed or Johns Manville will be acceptable, if they comply with the specifications.
   E. Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
   F. All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.

PART 3 - EXECUTION
3.01 INSTALLATION
   A. All insulation shall be installed in accordance with the manufacturer’s recommendations and printed installation instructions.
   B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.

END OF SECTION
SECTION 23 07 19

HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 SCOPE

A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for Owner's use.

B. Furnish and install piping insulation to:
   1. Chilled water and heating hot water piping.
   2. Condensate drain piping.
   3. Refrigerant piping.
   4. All pipes subject to freezing conditions shall be insulated.

C. Work specified elsewhere.
   1. Painting.
   2. Pipe hangers and supports.

D. For insulation purpose piping is defined as the complete piping system including supplies and returns, pipes, valves, automatic control valve bodies, fittings, flanges, strainers, thermometer well, unions, reducing stations, and orifice assemblies.

1.03 RELATED SECTIONS

A. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC

B. Section 23 05 53 - Identification for HVAC Piping and Equipment

C. Section 23 21 13 - Above Ground Hydronic Piping

D. Section 23 21 16 - Underground Hydronic Piping

1.04 REFERENCE STANDARDS


1.05 WARRANTY

A. Warrant the Work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from either defective or nonconforming materials or workmanship.

B. Defects shall include, but not be limited to, the following:
   1. Mildewing.
2. Peeling, cracking, and blistering.
3. Condensation on exterior surfaces.

1.06 SUBMITTALS
A. SHOP DRAWINGS: Indicate size, material, and finish. Show locations and installation procedures. Include details of joints, attachments, and clearances.
B. PRODUCT DATA: Submit schedules, charts, literature, and illustrations to indicate the performance, fabrication procedures, project variations, and accessories.

1.07 DELIVERY AND STORAGE
A. Deliver insulation, coverings, cements, adhesives, and coatings to site in unopened containers with manufacturer’s stamp, clearly labeled with flame and smoke rating, affixed showing fire hazard indexes of products.
B. Protect insulation against dirt, water and chemical and mechanical damage. Do not install damaged or wet insulation; remove such from project site.

PART 2 - PRODUCTS

2.01 HVAC PIPING INSULATION
A. It is the intent of these specifications to secure superior quality workmanship resulting in an absolutely satisfactory installation of insulation from the standpoint of both function and appearance. Particular attention shall be given to valves, fittings, pumps, etc., requiring low temperature insulation to insure full thickness of insulation and proper application of the vapor seal. All flaps of vapor barrier jackets and/or canvas covering must be neatly and securely smoothed and sealed down.
B. The type of insulation and its installation shall be in strict accordance with these specifications for each service, and the application technique shall be as recommended by the manufacturer. All insulation types, together with adhesives and finishes shall be submitted and reviewed prior to installation.
C. A sample quantity of each type of insulation and each type application shall be installed and accepted prior to proceeding with the main body of the work. Condensation caused by improper installation of insulation shall be corrected by Installing Contractor. Any damage caused by condensation shall be made good at no cost to the Owner or Architect/Engineer.
D. All insulation shall be listed and labeled to have a composite (insulation, jacket or facing, and adhesive used to adhere the facing or jacket to insulation) flame spread index of not more than 25 and smoke-developed index of not more than 50 when tested in accordance with ASTM E84 and UL 723.
E. All HVAC piping insulation shall comply with minimum requirements of ICC (IECC) and ASHRAE Std 90.1 I-P.
F. Accessories, such as adhesives, mastics and cements shall have the same component ratings as listed above.
G. All products or their shipping cartons shall have a label affixed, indicating flame and smoke ratings do not exceed the above requirements.
H. Any existing piping located in an air plenum that is comprised of materials that do not comply with the 25/50 flame and smoke rating per ASTM E84 testing requirements shall be provided with a single layer of high-temperature insulation to establish a noncombustible rating per ASTM E136. Insulation products which are approved for such non-compliant combustible piping materials located air plenums shall be 3M Fire Barrier Plenum Wrap 5A+ or Unifrax FyreWrap 0.5 Plenum. Insulation products for this application shall be installed in strict accordance with the manufacturer’s instructions.

2.02 APPROVED MANUFACTURERS
A. Calcium silicate materials shall be as manufactured by Johns Manville.
B. Glass mineral wool materials shall be as manufactured by Knauf Insulation, Johns Manville or Owens-Corning and shall have the same thermal properties, density, fire rating, vapor barrier, etc., as the types specified herein, subject to review by the Engineer. All glass mineral wool insulation shall be UL GREENGUARD Gold certified.
C. Adhesives shall be as manufactured by Childers, Foster, HB Fuller or Armacell, and shall have the same adhesive properties, fire rating, vapor seal, etc., as the types specified
herein, subject to review by the Engineer.

D. Flexible elastomeric cellular thermal insulation by Armacell.

E. Phenolic foam insulation shall be as manufactured by Resolco, Inc. (Insul-Phen) or Polyguard (Poly-phen).

F. Metal jacketing and fitting covers shall be as manufactured by Childers or RPR Products.

2.03 MATERIALS

A. HEATING HOT WATER PIPE: Provide glass mineral wool pipe insulation in accordance with ASTM C547 with ASJ-SSL jacket or phenolic foam in accordance with ASTM C1126 with ASJ and all joints sealed.

B. CONDENSATE DRAINAGE PIPING: Provide flexible elastomeric cellular thermal insulation in accordance with ASTM C534/C534M, model "Armaflex Ultra", fire rated for use in environmental air plenums; insulation not required when piping is exposed on roof.


D. ALL SERVICE JACKETING (ASJ): Vapor retarder jacket for interior applications shall be composed of an aluminum foil layer, reinforced with glass scrim, bonded to a layer of white kraft paper, interleaving with an outer polymer film leaving no paper exposed; complying with ASTM C1136. Vapor retarder jacket for exterior applications shall be composed of a 3-ply composite membrane consisting of a white 0.5 mil polyester film, 1.0 mil aluminum foil, and one 0.5 mil clear polyester film; complying with ASTM C1136.

PART 3 - EXECUTION

3.01 GENERAL

A. All insulation shall be installed in accordance with the manufacturer’s recommendations and printed installation instructions, including high density inserts at all hangers and pipe supports to prevent compression of insulation.

B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.

C. All heat recovery piping between air conditioning equipment and hydronic or domestic hot water piping shall be insulated per the High Temperature Surfaces Schedule below.

D. All condenser water piping located in a ceiling plenum shall be insulated per the Low Temperature Surfaces Schedule below.

E. Pipes located outdoors or in tunnels shall be insulated same as concealed piping and shall have a jacket of 0.016 inch thick, smooth aluminum with longitudinal modified Pittsburg Z-Lock seam and 2 inch overlap. Jacketing shall be easily removed and replaced without damage. All insulation butt joints shall be sealed with gray silicone. Galvanized banding is not acceptable.

F. All insulated piping located over driveways shall have an aluminum shield permanently banded over insulation to protect it from damage from car antennas.

G. Provide all HVAC piping insulation to comply with the ASHRAE Std 90.1 I-P Minimum Thickness Schedule and as indicated below.

1. Minimum Insulation Thickness for Low Temperature Surfaces
   a. Condensate drain lines: 1 inch
   b. Chilled Water Piping:
      1) Located outdoors: 2 inch
      2) Located indoors:
         a) 4 inch and smaller: 1-1/2 inch
         b) Larger than 4 inch: 2 inch

2. Minimum Insulation Thickness for High Temperature Surfaces
   a. Hot Water Piping:
      1) Operating temperature 105°F or less: 1 inch
      2) Operating temperature higher than 105°F and pipe size 1-1/4 inch or smaller:
         1-1/2 inch
      3) Operating temperature higher than 105°F and pipe size greater than 1-1/4 inch: 2 inch
b. Steam Piping:
   1) Pipe size 1-½ inch and smaller: 2-½ inch
   2) Pipe size more than 1-½ inch: 3 inch

3.02 WATER PIPE INSULATION INSTALLATION
A. The insulation shall be applied to clean, dry pipes with all joints firmly butted together. Where piping is interrupted by fittings, flanges, valves or hangers and at intervals not to exceed 25 feet on straight runs, an isolating seal shall be formed between the vapor barrier jacket and the bare pipe. The seal shall be by the applications of adhesive to the exposed insulation joint faces, carried continuously down to and along 4 inches of pipe and up to and along 2 inches of jacket.
B. Pipe fittings and valves shall be insulated with pre-molded or shop fabricated glass mineral wool covers finished with two brush coats of vapor barrier mastic reinforced with glass fabric.
C. All under lap surfaces shall be clean and free of dust, etc. before the Joint is sealed. These laps shall be firmly rubbed to insure a positive seal. A brush coat of vapor retarder shall be applied to all edges of the vapor barrier jacket.

3.03 FIRE RATED INSULATION
A. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe.
B. The penetration shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty.
C. All fire rating material shall be insulated in accordance with manufacturer's printed instructions.

END OF SECTION
SECTION 23 08 00
COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract Documents, including General and Supplementary Conditions and Division 01 Specifications, apply to this section.
B. Related Sections:
   1. Section 01 91 00 - General Commissioning Requirements
   2. Section 23 09 63 - Energy Management and Control System (EMCS)

1.02 SUMMARY
A. The commissioning of the HVAC system and associated controls shall be performed by an impartial technical firm hired by the owner. The commissioning provider shall be certified under one or more of the following certifications:
   1. CxA - Certified Commissioning Authority - ACG
   2. CBCP - Certified Building Commissioning Professional - AEE
   3. CCP - Certified Commissioning Professional - BCA
   4. CPMP - Certified Process Management Professional - ASHRAE
   5. BSC - Building System Commissioning Certification - NEBB
B. The commissioning provider (Commissioning authority) shall be responsible for leading the entire construction team through the commissioning process including, but not limited to, conducting the commissioning kick-off meeting, preparing the commissioning plan, preparing pre-functional checklists, preparing functional test scripts, participation in functional testing and preparation of required documentation and reports.

1.03 RESPONSIBILITIES
A. Contractor: Responsibilities of the Contractor as related to the Commissioning Process include, but are not limited to the following:
   1. Facilitate coordination of Commissioning work by Commissioning authority.
   2. Attend Commissioning meetings or other meetings called by Commissioning authority to facilitate the Commissioning Process.
   3. Review Functional Performance Test procedures for feasibility, safety, and impact on warranty, and provide Commissioning authority with written comment on same.
   4. Provide all documentation relating to manufacturer’s recommended performance testing of equipment and systems.
   5. Provide Operations & Maintenance data to Commissioning authority for preparation of checklists and training manuals.
   7. Provide As-built drawings and documentation to facilitate Testing.
   8. Assure and facilitate participation and cooperation of Sub Contractors and equipment suppliers as required for the Commissioning Process.
   9. Certify to Commissioning authority that installation work listed in Pre-Functional Checklists has been completed.
   10. Install systems and equipment in strict conformance with project specifications, manufacturer’s recommended installation procedures, and Pre-Functional Checklists.
   11. Provide data concerning performance, installation, and start-up of systems.
   12. Provide copy of manufacturers filled-out start-up forms for equipment and systems.
   13. Ensure systems have been started and fully checked for proper operation prior to arranging for Testing with Commissioning authority. Prepare and submit to Commissioning authority written certification that each piece of equipment and/or system has been started according to manufacturer’s recommended procedure, and that system has been tested for compliance with operational requirements.
      a. Contractor shall carry out manufacturer’s recommended start-up and testing procedures, regardless of whether or not they are specifically listed in Pre-Functional Checklists.
      b. Contractor is not relieved of obligation for systems/equipment demonstration where performance testing is required by specifications, but a Functional
Performance Test is not specifically designated by Commissioning authority.

14. Coordinate with Commissioning authority to determine mutually acceptable date of Functional Performance Tests.

15. Provide qualified personnel to assist and participate in Commissioning.

16. Provide test instruments and communications devices, as prescribed by Commissioning authority, required for carrying out Testing of systems.

17. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Test Engineer in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.

18. Ensure deficiencies found in the Commissioning Issues Log are corrected within the time schedule shown in the Commissioning Plan.

19. Provide Commissioning authority with all submittals, start-up instructions manuals, operating parameters, and other pertinent information related to Commissioning Process. This information shall be routed through Architect.

20. Prepare and submit to Commissioning authority proposed Training Program outline for each system.

21. Coordinate and provide training of Owner’s personnel.

22. Prepare Operation & Maintenance Manuals and As-Built drawings in accordance with specifications; submit copy to Commissioning authority in addition to other contractually required submissions. Revise and resubmit manuals in accordance with Design Professionals and Commissioning authority comments.

23. Commissioning requires participation of this Division Subcontractors to ensure that systems are operating in manner consistent with Contract Documents. All costs associated with the participation of Contractor, Sub-Contractors, Design Professionals, and Equipment Vendors in the Commissioning Process shall be included as part of the Construction Contract.

B. Subcontractors and vendors shall prepare and submit to Commissioning authority proposed Startup procedures to demonstrate proper installation of systems, according to these specifications and checklists prepared by Commissioning authority

1.04 COMMISSIONING PLAN

A. Commissioning Process tasks and activities:

1. Commissioning kick-off meeting: Conducted by commissioning authority and attended by construction team and design team.

2. Pre-functional checklists: Prepared by the commissioning authority and filled out by subcontractors performing the work that is applicable.

3. Site visits to review installation of applicable systems and progress of checklist documentation performed and reported by commissioning authority.

4. Functional testing: Commissioning authority shall conduct functional testing with assistance of applicable subcontractors and document successful results as well as deficiencies (issues). Functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing in accordance with plans and specifications. Testing shall include all modes and sequence of operation, including under full-load, part-load and emergency conditions (including all alarms). Controls system shall be tested to document that control devices, components, equipment and systems are calibrated and adjusted and operate in accordance with the plans and specifications. Sequences shall be functionally tested to document they operate in accordance with plans and specifications.

5. Preliminary commissioning report: Commissioning authority shall issue a preliminary commissioning report to the owner that has results of the first round of functional testing including deficiencies discovered.

6. Air and hydronic system balancing: Air and water flow rates shall be measured and adjusted to deliver final flow rates within the tolerances provided in the contract documents. System balancing shall be performed by TAB contractor as specified in the Testing, Adjusting and Balancing specification section 23.05.93.

7. Systems manual: Commissioning authority shall compile the systems manual using submittal data provided by the general contractor and applicable subcontractors.
8. Final commissioning report: Commissioning authority shall issue final commissioning report documenting the entire process and final results of functional testing. Report shall include final testing and balancing report.

B. Equipment to be tested
   1. Energy Management and Control System:
      a. Graphical User Interface
      b. Automation Software
      c. Field Level Controllers
      d. Field Level Devices
      e. Control Sequences
   2. Chilled Water Systems (All chillers and pumps)
   3. Heating Water Systems (All boilers and pumps)
   4. Air Handling Systems (All AHU and 10% of terminal units)
   5. Service water heating systems (100%)

C. Testing functions and conditions
   1. Energy conservation programs (economizer, optimal start, etc)
   2. Verify shutdown of systems when scheduled.
   3. Calibration of sensors
   4. Testing shall affirm winter and summer design conditions.
   5. Test under full outside air conditions.
   6. Confirm functionality of all specified sequences of operations.
   7. Verify the functionality of all alarms.

D. Performance criteria
   1. Air and water temperatures shall be within tolerances specified in the contract documents.
   2. Space temperatures shall be maintained within 1 degree of specified set points.
   3. Space humidity shall be maintained within 5% of specified levels.

PART 2 - PRODUCTS

2.01 NO PRODUCTS SUPPLIED

PART 3 - EXECUTION

3.01 GENERAL
   A. This Division has startup responsibilities and are required to complete sub-systems so COMPLETE SYSTEMS are fully functional. Insuring they meet design requirements of Contract Documents. Commissioning procedures and testing do not relieve or lessen this responsibility or shift this responsibility, in whole or in part, to Commissioning Agent or Owner.

   B. Coordinate with other Sub-Contractors and equipment vendors to set aside adequate time to address Pre-Functional Checklists, Functional Performance Tests, Operations & Maintenance Manual creation, Owner Training, and associated coordination meetings.

   C. Commissioning authority will also conduct site inspections at critical times and issue Cx Field Reports with observations on installation deficiencies so that they may be issued by Architect as deemed appropriate.

3.02 WORK PRIOR TO COMMISSIONING
   A. Complete all phases of the work so the systems can be started, adjusted, balanced, tested, and otherwise tested.

   B. See pertinent specification sections in this Division, which outline responsibilities for start-up of equipment with obligations to complete systems, including all sub-systems so that they are fully functional.

   C. Assist commissioning authority with all information pertaining to actual equipment and installation as required complete the full commissioning scope.

   D. Contractor shall prepare startup procedures to demonstrate compliance with pre-functional checklists, and coordinate scheduling for completion of these checklists.

   E. A minimum of 7 days prior to date of system startup, submit to Commissioning authority for review, detailed description of equipment start-up procedures which contractor proposes to
perform to demonstrate conformance of systems to specifications and Checklists.

3.03 PARTICIPATION IN COMMISSIONING
A. Attend meetings related to the Commissioning Process; arrange for attendance by personnel and vendors directly involved in the project, prior to testing of their systems.
B. Provide skilled technicians to startup and test all systems, and place systems in complete and fully functioning service in accordance with Contract Documents.
C. Provide skilled technicians, experienced and familiar with systems being commissioned, to assist Commissioning authority in commissioning process.

3.04 WORK TO RESOLVE DEFICIENCIES
A. Complete corrective work in a timely manner to allow expeditious completion of Commissioning Process. If deadlines pass without resolution of identified problems, Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs thus incurred will be Contractor’s responsibility.

3.05 PRE-FUNCTIONAL CHECKLISTS (PFC)
A. Contractor shall complete Pre-Functional Checklists to validate compliance with Contract Documents installation and start-up requirements, for this Division’s systems.
B. Refer to commissioning plan for detailed list of equipment to be commissioned.

3.06 FUNCTIONAL PERFORMANCE TESTING (FPT)
A. Contractor, in cooperation with Commissioning Agent, shall conduct Functional Performance Testing to validate compliance with Contract Documents.
B. Refer to commissioning plan for detailed list of equipment to be commissioned.
C. Assist Commissioning authority in Functional Testing by removing equipment covers, opening access panels, etc. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.
D. DBR has included a small contingency for limited retesting, however DBR reserves the right to stop testing on a system when the system:
   1. Does not have the correct graphics programmed.
   2. Does not have the correct data trends programmed.
   3. Does not have the correct set points programmed.
   4. Does not have the equipment or system safeties installed and programmed correctly.
   5. The TAB data forms have not been submitted to our firm or the performance of the system listed on the TAB forms is not per project requirements.
   6. Line items of the functional performance test have failed.
E. Sampling
   1. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy.
   2. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. It is noted that no sampling by Subs is allowed in pre-functional checklist execution.
   3. A common sampling strategy is the "xx% Sampling - yy% Failure Rule", defined by the following example.
      a. xx = the percent of the group of identical equipment to be included in each sample.
      b. yy = the percent of the sample that if failing, will require another sample to be tested.
      c. The example below describes a 20% Sampling - 10% Failure Rule.
      d. Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the "first sample."
      e. If 10% (yy) of the units in the first sample fail the functional tests, test another 20% of the group (the second sample).
      f. If 10% of the units in the second sample fail, test all remaining units in the whole group.
g. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.

F. Re-Testing And Failure To Remedy Deficiencies
1. Despite Contractor’s best efforts to ensure systems are problem-free, it is expected that some deficiencies will be found during initial inspection of Pre-functional Checklist, and during initial Functional Testing; such deficiencies are expected to be minimal.
2. It is Contractor’s responsibility to remedy identified deficiencies, both in Pre-functional Checklist and in Functional Testing phases of work, in a timely and thorough manner.
3. It is Contractor’s responsibility to ensure that all deficiencies are corrected prior to requesting a re-inspection or re-test of systems and equipment. Do not request re-inspection or re-test until deficiencies are corrected.
   a. At his discretion, CxA may agree to re-testing systems or equipment where deficiencies remain which are beyond Contractor’s control to resolve expeditiously.
   b. Typically such re-testing of incomplete systems and equipment will take place only if remaining deficiencies are minor in scope and nature, and are of such nature that they cannot be resolved in a timely manner (such as those due to difficulties in obtaining parts, or where Owner has requested a change that has delayed work, etc.)
4. CxA will carry out a second re-inspection or re-test of systems and equipment subsequent to receiving Contractor’s request.
   a. If CxA finds deficiencies identified in initial inspection or test have not been remedied (with exception of un-resolvable deficiencies in 3.b. above), and such remaining deficiencies are significant enough to require additional inspection or re-testing, Contractor will be back-charged for CxA’s expenses, and time at a rate of $150.00 per hour and $100.00 expenses, for a third and any subsequent re-inspections and re-tests.

G. Deferred Testing
1. “Seasonal Commissioning” pertains to testing during peak heating or cooling seasons when HVAC equipment is operating at full-load or heavy-load conditions. Initial commissioning will be done as soon as contract work is completed, regardless of season. Seasonal Commissioning under full- or heavy-load conditions other than the current season will be handled at later time by GC and CxA.
2. If adequate load may be artificially placed upon heating or cooling equipment, CxA, at his discretion, may perform functional testing during non-peak load periods.
3. GC is to provide services of personnel and participate in seasonal testing process in the same manner as he would in non-seasonal testing.
4. Until off-season commissioning can be accomplished, Owner may retain an amount from GC’s payment sufficient to cover the cost of off-season testing.
5. Unforeseen Deferred Tests: If any check or test cannot be completed due to building structure, required occupancy condition, or other reason, execution of checklists and functional testing may be delayed upon approval of Owner. Tests shall be conducted in same manner as seasonal tests, as soon as possible. Services of required parties will be negotiated. Make final adjustments to Operation and Maintenance Manuals and record drawings due to unforeseen deferred tests.
6. GC is to provide services of personnel and participate in deferred testing in the same manner as he would for normal commissioning.

3.07 TRAINING
A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.

B. Contractor shall be responsible for training coordination and scheduling, and ultimately to ensure that training is completed.

C. The training agenda (plan) shall include, at a minimum, the following elements:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions.
5. Most likely failure modes, causes and corrections.
6. On site demonstration.

D. Commissioning authority shall be responsible for overseeing and approving content and adequacy of training of Owner personnel for all installed systems. Provide Commissioning authority with training plan two weeks before planned training.

3.08 OPERATIONS & MAINTENANCE MANUALS

A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.

B. Sub-Contractor shall compile and prepare documentation for equipment and systems specified in this Division, and shall deliver documentation to Contractor for inclusion in Operation & Maintenance Manuals, in accordance with requirements of Division 01, prior to training Owner personnel.


D. Operation and maintenance manuals shall include, service agency contact information, maintenance requirements, controls system settings and a narrative of how each system is intended to operate, including set points.

3.09 DOCUMENTATION

A. Commissioning authority shall provide documentation of process as follows:

1. Preliminary commissioning report including test procedures, results of testing, itemization of deficiencies, deferred tests and climatic conditions required for performance of deferred tests. Preliminary commissioning report shall be issued to owner to demonstrate the first pass of testing has occurred and to demonstrate compliance with applicable codes.

2. Final commissioning report shall include the final test and balance report, final results of functional testing, disposition of deficiencies discovered during testing, including the details of corrective measures used and functional testing procedures used for repeatability of testing in the future.

END OF SECTION
SECTION 23 09 63
ENERGY MANAGEMENT AND CONTROL SYSTEM (EMCS)

PART 1 - GENERAL

1.01 GENERAL

A. The Energy Management and Control System (EMCS) shall be comprised of a Local Area Network (LAN) infrastructure, Operator Workstations (OWS), Engineering Workstations (EWS), a Primary Network Server (PNS), Network Area Controllers (NAC), Application Specific Controllers (ASC), Unitary System Controllers (USC), and Field Devices installed within the facility.


C. If the EMCS contractor wishes to connect to the Owner’s Wide Area/Local Area Network as part of the control system network, the EMCS contractor shall acquire permission in writing and include the letter in the submittal. Any system that requires connection to the owner’s network for communication between NAC, ASC, USC and/or field devices that is submitted without the written permission from the owner shall be rejected. The EMCS Contractor shall coordinate with the Owner and supply all required information.

D. Access to the system, either locally in the building, or remotely from a central site or sites, shall be accomplished through standard web browsers, via the Internet and/or a local area network.

E. All EMCS controllers and workstations shall communicate using the protocols and network standards as defined by ANSI/ASHRAE Standard 135-2010, latest revision. Management level TCP/IP Ethernet network speeds shall be 1 Gbps minimum and the Automation Level MS/TP network speeds shall be 76.8 Kbps minimum.

F. The Server shall gather data from the system and generate HTML pages accessible through a conventional web browser from all personal computers (PCs) connected to the network. System shall include any and all software and hardware to support at least 50 simultaneous users. The EMCS shall be compatible with all common web browsers.

G. Facility Operators shall be able to view and configure systems through the standard web browser and all graphical/data representations shall appear identical, whether the user is on site or viewing via the Internet at a remote location. Standard operator functions such as control point manipulation, configuration and viewing of trends, schedules and alarms shall be performed through the standard browser. Each mechanical system and building floor plan shall be depicted on the operator workstation by point-and-click graphics.

H. The EMCS shall directly control HVAC equipment as specified in the Sequence of Operations. Furnish Energy Conservation features such as Optimal Start/Stop, Night Setback, Setpoint Reset logic, and Demand Control Ventilation.

I. The EMCS vendor shall provide the following additional services as part of this specification: warranty and service during the warranty period; submittals, samples and record documentation; comprehensive startup and testing of the EMCS with documentation; training services for the owner and facility operators; coordination with other contractors and suppliers; operator and technician training program, and shall cooperate fully with the Project Commissioning Agent.

J. Products furnished under this specification but installed by other.
   1. Mechanical devices installed under Division 23 by the mechanical contractor or other suppliers: temperature sensing thermowells; automatic control valves; pipe taps for flowmeters; water pressure sensors and switches; automatic control dampers not installed in air handling unit mixing boxes or louver schedules; damper actuators for variable air volume (VAV) terminal units; mounting cost of controller and actuator for VAV terminal units.
   2. Electrical devices installed under Division 26 by the electrical contractor:
      a. 120 VAC power to controllers and control panels at locations indicated on the drawings. Review and verify that these locations are adequate for the proposed
EMCS.
b. Interlock wiring to duct mounted smoke detector or fire alarm shutdown relays to HVAC equipment motor starters and variable frequency drives (VFD).

K. Provide and install all interconnecting cables between all operator’s terminals and peripheral devices (such as printers, etc.) supplied under this section.

1.02 RELATED DOCUMENTS & REFERENCES
A. Drawings and general provisions of the contract documents, apply to this section including:
   1. Division 01 for General Conditions and Supplementary Conditions.
   2. Division 23 for mechanical equipment, ductwork, and piping systems.
   3. Division 26 for electrical equipment, lighting control, and fire alarm systems.
B. The latest edition of the following standards and codes in effect as approved by the authority having jurisdiction and amended as of supplier’s proposal date, and any applicable subsections thereof, shall govern design and selection of equipment and material supplied:
   1. ANSI MC85.1 - Terminology for Automatic Control.
   2. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE).
   4. BTL Mark by the BACnet Testing Laboratories.
   5. International Building Code (IBC), including local amendments.
   6. UL 916 Underwriters Laboratories Standard for Energy Management Equipment. Canada and the US.
   8. FCC Part 15, Subpart J, Class A.

1.03 RELATED WORK IN OTHER SECTIONS
A. Refer to Division 00 and Division 01 for allowances and related contractual requirements.
B. Refer to Division 23 for General Mechanical Provisions for equipment such as chillers, cooling towers, boilers, pumps, air-handling units, terminal units, ventilation fans, variable frequency drives, unitary AC units, etc.
   1. The EMCS contractor shall provide communications integration via BACnet/IP interface to each installed system listed above. BACnet MS/TP acceptable if IP interface is not available from equipment manufacturer.
   2. The EMCS contractor shall coordinate with all vendors providing above systems to obtain communications requirements and points lists. Map all available points to EMCS.

1.04 ELECTRICAL POWER PROVISIONS
A. Primary power will be provided under Division 26 by the electrical contractor to the panel locations indicated on the mechanical & electrical drawings. Provide step down transformers within panel enclosures. Provide all necessary fuses and circuit protection devices.
B. Power will be provided to the controllers serving fan powered terminal units with electric heat via the control transformer provided with the unit.
C. All components of the EMCS shall be powered from the sources above. Provide final terminations from the locations indicated on the Division 23 Drawings.
D. The EMCS Contractor shall provide any additional control power that is required as part of this contract and not indicated by other. This shall include all conduit, cabling, circuit breakers, etc.

1.05 CONTRACTOR QUALIFICATIONS
A. The EMCS Contractor shall:
   1. Have a local staff of trained personnel capable of giving instructions and providing routine and emergency maintenance on the EMCS, all components and software/firmware and all other elements of the EMCS.
2. Have a proven record of experience in the supply and installation of equivalent BACnet systems over a minimum period of five years. Provide documentation of at least three equal and complexity, if so requested by the Owner's Representative.
3. Be a factory certified representative of the native BACnet EMCS manufacturer for design, installation, and service of the proposed system.
4. Have comprehensive local service, training and support facilities for the total EMCS as provided. Maintain local, supplies of essential expendable parts.

1.06 SUBMITTALS
A. ALL DOCUMENTS SUBMITTED SHALL BE IN NATIVE PDF FORMAT. NO SCANS.
B. Shop Drawings:
1. The following information shall be included on the cover page for each shop drawing and equipment documentation submittal:
   a. Project name with date. Refer to the applicable specifications by name and number.
   b. Provide submittal number and re-submittal number and date as applicable.
   c. Provided name and address of Consulting Engineer, Mechanical Contractor, General Contractor
2. Shop drawings shall be CAD generated, plot size of 8-1/2" x 11" or 11" x 17". Drawings shall include diagrams, mounting instructions, installation procedures, equipment details and software descriptions for all aspects of the system to be installed.
3. Provide schematic of systems indicating instrumentation locations, all interconnecting cables between supplied cabinets on a mechanical floor plan.
4. Software specifications and descriptions including operating sequences.
5. Provide a bill of material that indicates specific manufacturer, part number, part description and quantity of each device for all system components.
6. Provide a list of the wire labels to be installed on each end of the control wiring, at the device and the control panel terminal. Labels shall be machine generated, typed and legible with a maximum of 17 characters. The label description “AHU-1 SAT” shall indicate the supply air temperature of AHU-1.
7. Equipment Schematic: Provide an electronic equipment schematic for each piece of mechanical equipment. The schematic shall display all mechanical equipment characteristics including fans, dampers, valves, sensors and other applicable control devices. The schematic shall show wiring terminations to each control device as shown in the submittal and as-build documentation. Control devices shall be labeled by a symbol that can easily be identified in a bill of material that is shown on this graphic. The bill of material shall show the device symbol, description, manufacture and part number.
8. Sequence of Operations: The control sequences shall be viewable for each piece of mechanical equipment and be in a text format as shown in the as built documentation. The sequence of operations shall be selectable at the applicable location for the control program.
C. Control component submittals:
1. Component technical data sheets with mounting and installation details.
2. The documentation shall include comprehensive and complete details of the BIBB and automation level documentation including address, associated controller type, etc. as required and for the interface to the EMCS.
3. Details of networks/communications equipment, cabling and protocols proposed. Provide schedule of cabling including details of proposed cable types.
4. Module Drawing: Provide an electronic wiring diagram of each control module (as shown in submittal documentation). Diagram shall display wiring schematic and terminations to end devices. Diagram shall display each input and output terminals and label those that are used for the control application. Diagram shall display module type/name and network address.
5. Field sensor and instrumentation specification sheets. Provide complete manufacturer’s specifications for all items that are supplied. Include vendor name of every item supplied.
6. Schedule and specification sheets for dampers, valves and actuators.
7. Design and provide layout of all components of panel mounted control devices, terminal strips and power supplies.

D. Colorgraphics: Provide sample layout of color graphic representations of the systems for review. The submittal shall indicate the quality of the graphic to be provided with the system with a sample of the specific control points to be included. Control points shall as a minimum include points indicated in the input/output summary, control schematic and primary controlling points defined in the sequences of operation. Provide a sample of a floor plan layout, typical AHU, terminal unit, outside air pretreatment unit, variable frequency drive, exhaust/supply fan, chiller plant and hot water plant. For control points to be provided by equipment BACnet integration provide sample of the control points, up to 25 total.

E. Verification Reports. The submittal shall include a sample of the verification reports to be utilized during the verification section of this specification. Sample reports shall be approved as submitted or be modified by the engineer or owner’s representative. The verification reports shall be included in the final Operation & Maintenance Manuals. Reports shall be provided in electronic PDF format.

1. Project Systems Verification Form for each controller.
   a. General information for each form shall include: project name; associated equipment with mark number; control panel number and location; controller number and model number; controller device instance number (address); MS/TP LAN segment number; verifying technician and date.
   b. Each connected control point and device shall contain the following columns with a separate line for each connected physical point: point description (same as device label); input/output number for each connected control device (AI-XX, AO-XX, DI-XX, or DO-XX).
   c. Check boxes confirming that the verification tasks have been completed: device location, proper termination at device; proper termination at control panel; sequence is verified; point trend is enabled.
   d. Data entry boxes indicating measured/confirmed values: preliminary control point value on the graphic; observed control point value; calibration or adjustment value to correct offset; final displayed point value on the color-graphic; date of verification; engineer or owner’s representative verification.

2. Control Panel Verification Form for each control panel.
   a. General information: panel location and identification number; panel dimensions and NEMA rating; panel properly installed; Class 1 and Class 2 wiring are properly separated; correct voltage to the panel; no shorts or grounds in panel; no induce voltages in panel wiring; point to point termination match submittal; devices are mounted in the correct location; controller software revision number; address of controllers; panel device checkout is complete; panel startup is complete.

3. Sequence of Operation Verification Form per piece of equipment (AHU, VAV, chiller, boiler, etc.).
   a. General information: project name; system identifier; building area served; control panel and controller numbers; controller model number and instance number (address); MS/TP LAN segment number; name of verifying technician and date.
   b. Each step of the sequence of operation for each piece of equipment shall be documented shall include a “description of test”, “input to trigger test” and “expected outcome”. A pass/fail checkbox shall indicate each of these actions. Provide space for technician approval with associated date.

F. Operating and Maintenance (O&M) manuals: Provide O&M manual with full information to allow the owner to operate, maintain and repair installed products. Include trade names with model numbers, color, dimensions and other physical characteristics.

1. Format: Produce on 8-1/2 x 11-inch pages, and bind in 3-ring/binders with durable plastic covers. Label binder covers with printed title “OPERATION AND MAINTENANCE MANUAL”, title of project, and subject matter and “Number _ of _” of binder. Provide substantial dividers tabbed and titled by section/component number.

2. Table of Contents for each volume:
   a. Part 1: Directory with name, address and telephone number of Designer, Contractor and Subcontractors and Suppliers for each Project Manual section.
b. Part 2: Operation and maintenance instructions, arranged by Project Manual Section number where practical and where not, by system. Include:

3. Product design criteria, functions, normal operating characteristic and limiting conditions. Installation, alignment, adjustment, checking instructions and troubleshooting guide. Operating instructions for start-up, normal operation, regulation and control, normal shutdown and emergency shutdown. Test data and performance curves.

4. Spare parts list for operating products, prepared by manufacturers including detailed drawings giving location of each maintainable part, lists of spares recommended for user-service inventory and nearest source of in-stock spares.

G. Record Documentation:
1. Details of all alarm, diagnostic, error and other messages. Detail the Operator action to be taken for each instance.
2. Detail special programs provided and provide a complete programming instruction manual. Detail operation of all software applications.
3. Detailed list of the database for all installed devices.
4. Record drawings shall be CAD generated and shall include final locations and point ID for each monitored and controlled device.
5. In addition to the required hard-copies, provide a CD-ROM with all of the record documentation in PDF format and a CD-ROM containing backup copies of all installed software and graphics.
6. Online as-built documentation: provide digital replications of as-buils that shall be accessible from each equipment graphic controlled or monitored by the EMCS.

1.07 WARRANTY

A. Warranty work and the equipment provided under this contract shall be for a period of one year from the date of Substantial Completion. Warranty shall cover all components, system software, parts and assemblies supplied by this contractor and shall be guaranteed against defects in materials and workmanship for one (1) year from the date of Substantial Completion. Labor to troubleshoot, repair, reprogram or replace system components that have failed due to defects in materials and workmanship shall be provided by this contractor at no charge to the owner during the warranty period. All corrective software modifications made during warranty service periods shall be updated on all user documentation and on user and manufacturer archived software disks. All warranty work shall be performed by the EMCS contractor's local service group.

B. Warranty shall not include routine maintenance, e.g., equipment cleaning, mechanical parts lubrication, pilot lamp replacement, operational testing, etc. Warranty shall not cover repair or replacement of equipment damaged by under- or over-voltage, misuse, lack of proper maintenance, lightning, water damage from weather or piping failure.

C. Hardware and software personnel supporting this warranty agreement shall provide on-site or off-site service in a timely manner after failure notification to the EMCS contractor. The maximum acceptable response time to provide this service at the site shall be 24 hours, during normal working hours.

1.08 OPERATIONS PERSONNEL TRAINING

A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:

1. Purpose of equipment.
2. Principle of how the equipment works.
3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions
5. Most likely failure modes, causes and corrections.
6. On site demonstration that includes hands-on demonstration of the manipulation of setpoints, schedules and other adjustable elements of the system.
7. The demonstration shall be on the actual, completed graphic interface pages for the specific project.

B. Provide a second training session 3 months after initial session for any follow-up or additional training requested by owner’s personnel. Allow 3 hours for the second training
1.09 OPERATOR WORKSTATION (OWS)
   A. The Operator Workstation shall be any personal computer, connected to the LAN, with appropriate web browser software installed.

1.10 ENGINEERING WORKSTATION (EWS)
   A. The Engineering Workstation shall be any personal computer, connected to the LAN, with a registered copy of the EMCS contractor supplied engineering and/or programming software installed. The EMCS contractor shall provide at least one copy of all required software(s), to enable the Owner complete editing/programming functions of all controllers, graphics, and control logic.
   B. The EMCS shall provide one personal computer (PC) which is compatible with the performance required by the EMCS Engineering Software if an engineering workstation is specified for the system.

PART 2 - PRODUCTS

2.01 ACCEPTABLE EMCS VENDORS
   A. Siemens

2.02 PRIMARY NETWORK SERVER (PNS)
   A. The EMCS Contractor shall provide and install the Primary Network Server as part of this system. The PNS shall utilize the Internet and provide efficient integration of standard open protocols. The PNS shall maintain comprehensive database management, alarm management and messaging services, and graphical user interface as follows:
      1. Support an unlimited number of users over the Internet/intranet with a standard web browser to access alarms, trend logs, graphics, schedules and configuration data. Access to the PNS shall be password protected utilizing authentication and encryption techniques. An audit trail of database changes indicating user, time stamp, and audit action shall be provided.
      2. Enterprise level information exchange using an SQL database and HTTP/HTML/XML text formats.
      3. Synchronize controller databases, database storage scheduling, control and energy management routines
      4. Alarm processing and routing which includes email, SMS text messages and paging.
      5. HTML based help system that includes comprehensive online system documentation.
      6. Support of multiple Network Area Controllers (NAC) connected to a Local Area Network.
   B. Server Functions
      1. It shall be possible to access all Network Area Controllers (NAC) via a single connection to the server through the Ethernet LAN. In this configuration, each Network Area Controller can be accessed from a single user login.
      2. The PNS shall provide the following functions, at a minimum:
         a. The server shall provide complete access to distributed global data. The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
         b. The server shall include a master clock service for its subsystems and provide time synchronization for all NACs.
         c. The server shall provide scheduling for all NACs and their underlying field control devices.
         d. The server shall provide demand limiting control that operates across all NACs. The network server shall be capable of multiple demand limiting programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
         e. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to NACs. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
f. The server shall provide central alarm management for all NACs supported by the server. Alarm management shall include: routing of alarms to a video display, a printer, an email and pager; view and acknowledge alarms; query alarm logs based on user-defined parameters.

g. The server shall provide central management of logged data for all NACs supported by the server. Logged data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include: viewing and printing log data; exporting log data to other software applications; query log data based on user-defined parameters.

3. The Primary Network Server shall be capable of supporting the following open system drivers:
   a. BACnet/IP

C. Network Server Platform Requirements
   1. Rack-Mounted Server Computer Hardware: DELL PowerEdge R220 or equal, Intel Pentium Core 2 Duo 2.0 GHz or higher, 8GB RAM, 500GB hard drive, video card, 22” color monitor, and Ethernet adapter 1Gbps or higher.
   2. Operating system software shall be Microsoft Windows 7 Professional or higher.

2.03 NETWORK AREA CONTROLLER (NAC)

A. Provide one or more Network Area Controllers (NAC) to meet the sequence of operations and the type and quantity of devices being integrated into the system. The NAC shall provide the interface between the local area network and the field controllers. The NAC shall provide global supervisory control functions over the associated controllers and shall be capable of executing application control programs to provide: calendar functions; scheduling; trending; alarm monitoring and routing; time synchronization; integration of controller data for each applicable protocol; network management functions for all network devices. The user may view real-time information via web-based data.

B. The Network Area Controller shall provide the following hardware features as a minimum: Ethernet Ports 100Mbps or higher, BACnet MS/TP ports, battery backup, DDR RAM memory, flash memory for long term data backup.

C. Provide an uninterruptible power source (UPS) per network controller to maintain operation for 1 hours.

D. The NAC shall be capable of operation over a temperature range of 32 to 122 °F and operation over a humidity range of 5 to 95% RH, non-condensing; storage temperatures of between 32 and 158 °F.

E. The NAC shall provide multiple user access to the system and support for ODBC or SQL. A database resident on the NAC shall be an ODBC-compliant database or must provide an ODBC data access mechanism to read and write data stored within it.

F. The NAC shall be capable of supporting the following open system drivers:
   1. BACnet/IP
   2. BACnet MS/TP

G. Event Alarm Notification and actions: The NAC shall provide alarm recognition, storage; routing, management; and analysis to supplement distributed capabilities of equipment or application specific controllers. Alarm conditions shall be routed to any defined user location whether connected to a local or wide-area network.
   1. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including but limited to: alarm; return to normal; fault.
   2. Provide for the creation of a minimum of eight alarm classes for the purpose of routing types and or classes of alarms, i.e.: security, HVAC, Fire, etc. Allow timed routing of alarms by class, object, group, or node.
   3. Provide alarm generation from binary object “runtime” and/or event counts for equipment maintenance (i.e. filter status, fan run status). Authorized users shall be able to reset runtime or event count values with appropriate password control.
   4. Control equipment and network failures shall be treated as alarms and annunciated.
   5. Alarms shall be annunciated in any of the following manners as defined by the user: screen message text; e-mail of the complete alarm message to multiple recipients. Provide the ability to route and email alarms based on: day of the week, time of day and recipient.
6. Color-graphic shall have flashing alarm object(s). Printed message may be routed directly to a dedicated alarm printer.

7. The following shall be recorded by the NAC for each alarm (at a minimum): time and date; location (building, floor, zone, office number, etc.); associated equipment. Upon acknowledgement of the alarm the NAC shall document the time, date and authorized user. The number of alarm occurrences since the last acknowledgement shall be recorded.

8. Defined users shall be given proper access to acknowledge any alarm, or specific types or classes of alarms defined by the user. Alarm actions may be initiated by user defined programmable objects created for that purpose.

9. Alarm archiving: A log of all alarms shall be maintained by the NAC and/or a server and shall be available for review by the user. Provide a “query” feature to allow review of specific alarms by user defined parameters. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

H. Data Collection and Storage: The NAC shall have the ability to collect data for any property of any object and store this data for future use.

1. The user shall designate the log as an interval log or deviation log. For an interval log, the object shall be configured for time of day, day of week and the sample collection interval. For deviation log, the object shall be configured for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full, or rollover the data on a first-in, first-out basis. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

2. All log data shall be stored in a relational database in the NAC and the data shall be accessed from the server or a standard web browser. All log data, when accessed from the server, shall be capable of being manipulated using standard SQL statements.

3. All log data shall be available to the user in the following data formats: HTML, XML, plain text, comma separated values, as a minimum.

4. The NAC shall have the ability to archive its log data either locally or remotely to the server or other NAC on the network.

I. Local Access: The NAC shall provide redundancy of system access to the local controllers at the remote building if the Primary Network Server should lose communication or be offline. The NAC shall maintain setpoint and scheduling features, access to the color-graphic displays, maintain trend logs and reports. Upon restoration of communication with the PNS the archived information shall be transmitted to the server for archiving.

2.04 SOFTWARE FOR THE NAC

A. The distributed architecture of the operating system for the PNS and NACs shall provide the operator a comprehensive interface to allow the operator to configure and customize the EMCS to optimize the HVAC system to save energy, schedule and maintain equipment and provide occupant comfort. The provided graphical toolset shall allow the operator to create applications in a drag and drop environment.

1. Input/output capability shall allow the operator to request the current value or status of the control point; command/override equipment to a specific state; add, change or delete control points, alarm limits and controllers; change descriptors to control points and equipment; modify parameters; create or modify DDC loops.

B. Operator System Access: Via software password with five access levels at workstations and at each control unit.

C. Color graphic tools shall allow the user to create equipment and floor plan graphics from a standard library of symbols; allow custom generation of symbols; utilize over 64 or more colors; create real-time dynamic data for the graphics. Up to 60 control points may be displayed on each graphic.

1. Provide a link between compatible graphics to minimize the paths to additional information. For example, provide the link from the zone sensor to the VAV terminal to the air handling unit and to the central plant. Web pages shall be provided to allow the operator to zoom into specific areas of the facility and then link the space to the floor plan to the overall building and then to the facility site plan.
Graphical tools shall allow the creation of bar graphs, pie graphs and other tools to visualize control information such as run time hours, energy consumed and occupant comfort.

Alarm processing tools shall allow the operator to create alarm messages that include as a minimum: time of alarm, point descriptor, alarm condition and remote annunciation. Critical alarms shall be displayed, archived to a storage device or printed on a alarm printer. Alarms shall be displayed in order of occurrence and have an optional audible alarm indicator.

1. Print alarm messages, up to 60 characters in length, for each alarm point specified.
2. Alarms may be routed to other devices including web-enabled cell phones, pagers, tablet PCs and designated personal computers on the network or Internet.
3. Operator specifies when alarm requires acknowledgment. Continue to indicate unacknowledged alarms after return to normal. An alarm log shall be maintained to archive alarms for future reference with the above specified parameters as well as indicating the person acknowledging the alarm.
4. The graphical display shall indicate the number of the current unacknowledged alarms by individual building site or by sum of all campus-wide facilities.
5. The operator may create and forward an e-mail message to another user directly from the graphical interface so that the message can be read when the second user logs on to the system.

Upon a power failure to equipment in the facility, the EMCS shall automatically start equipment upon the restoration of power. Program a time delay between individual equipment restart on a schedule to minimize demand charges from the utility company.

Custom reports may be created by the operator with a requested time and date manually or automatically. All reports may be logged to a storage device for future reference. The data reports shall allow customization and scaling of the X-Y coordinates; plotting of tabular reports; provide multi-point graphical reports with not less than eight variables on the same report. Print reports on daily, weekly, monthly, yearly or scheduled basis as scheduled.

The network server current operating system, database, color-graphics, custom reports shall be backed up automatically to a remote server or storage device as directed by the owner’s representative.

Maintenance Management capability shall allow the system to monitor and log the run-time for HVAC equipment; schedule maintenance reports that include recommended material and labor for the assigned task.

**2.05 APPLICATION SPECIFIC CONTROLLERS (ASC)**

All devices required for single loop control shall be terminated on a single controller. (for example, CHW loop pressure control. The differential pressure sensor and the pump VFD ramp signal.)

ASCs shall be capable of implementing control strategies for the system based on information from any or all connected inputs. The AC shall utilize factory pre-programmed global strategies that may be modified by field personnel on-site. Global control algorithms and automated control functions should execute via a 32-bit processor.

Programming shall be object-oriented using control program blocks that will support a minimum of 500 Analog Values and 500 Binary Values. Analog and binary values shall support standard BACnet priority arrays. Provide means to graphically view inputs and outputs to each program block in real-time as program is executing.

Controller shall have adequate data storage to ensure high performance and data reliability. Battery shall retain static RAM memory and real-time clock functions for a minimum of 1 year (cumulative). Battery shall be a field-replaceable (non-rechargeable) lithium type. The onboard, battery-backed real time clock must support schedule operations and trend logs.

The base unit of the ASC shall host various I/O combinations including universal inputs, binary outputs, and switch selectable analog outputs (0-10V or 0-20 mA). Inputs shall support thermistors, 0-5VDC, 0-10VDC, 4-20mA, dry contacts and pulse inputs directly.

All binary outputs shall have onboard Hand-Off-Auto switches and a status indicator light. HOA switch position shall be monitored. The position of each HOA switch shall be available system wide as a BACnet object.
G. Controller shall be capable of BACnet communication. BACnet Conformance:
   1. Standard BACnet object types supported shall include as a minimum: Analog Input, Binary Input, Analog Output, Binary Output, Analog Value, Binary Value, Device, File, Group, Event Enrollment, Notification Class, Program and Schedule object types. All necessary tools shall be supplied for working with proprietary information.

H. Schedules: Each ASC shall support a minimum of 10 BACnet schedule objects.

I. Logging Capabilities: Each controller shall support a minimum of 100 trend logs. Sample time interval shall be adjustable at the operator’s workstation. Controller shall periodically upload trended data to system server for long term archiving if desired. Archived data stored in database format shall be available for use in third-party spreadsheet or database programs.

J. Alarm Generation: Alarms may be generated within the system for any object change of value or state either real or calculated. This includes things such as analog object value changes, binary object state changes, and various controller communication failures. Alarm logs shall be provided for alarm viewing. Log may be viewed on-site at the operator’s terminal or off-site via remote communications. Controller must be able to handle up to 200 alarm setups stored as BACnet event enrollment objects -system destination and actions individually configurable.

2.06 UNITARY SYSTEM CONTROLLERS (USC)

A. All devices required for single loop control shall be terminated on a single controller. (for example, cooling coil control valve control. The temperature sensor and the valve control signal.)

B. The EMCS Contractor shall provide all Unitary System Controllers. USC shall be fully programmable or applications specific controllers with pre-packaged operating sequences maintained in Flash RAM.

C. The USC shall be a node on the automation network and shall control its own communications so that the failure of any one node, shall not inhibit communications on the network between the remaining nodes. USC shall be totally independent of other network nodes for their monitoring and control functions.

D. Provide each USC with a battery back-up for the protection of volatile memory for a minimum of 72 hours. Batteries shall be rated for a seven-year life.

E. All associated applications programs shall reside at the USC. The USC shall not require communication to any other panel for normal operating sequences other than time scheduled base commands.

F. Control shall be based on algorithms, i.e. proportional plus integral plus derivative (PID), proportional plus integral (PI), or proportional to comply with the sequences of operation PID algorithms shall maintain the system operation within +/- 2% of setpoint.

G. The USC shall be configured with sufficient input/output capacity to achieve the required control points to meet the sequence of operations.

2.07 AIR HANDLING UNIT CONTROLLER

A. All devices required for single loop control shall be terminated on a single controller. (for example, AHU static pressure control. The differential pressure sensor and the VFD ramp signal.)

B. The EMCS Contractor shall provide controllers required for chilled/hot water and DX/electric heat air handling units and fan coil units. Provide an enclosure to house the controller and associated components including suitable mounting brackets shall be NEMA 1 rated and located outside the FCUs.

C. The controller shall be capable of monitoring and controlling the following parameters per the sequences of operation and input/output summary; space temperature; space relative humidity sensor; cooling/heating stage control or modulating valve control; fan on/off control and status; supply air sensor; occupancy sensor; carbon dioxide sensor; VFD control and monitoring.

2.08 EMCS CONTROLLER LEVEL NETWORK

A. EMCS Automation Level Network shall consist of BACnet MS/TP (76.8 Kbps minimum). Data transfer rate and data throughput as required to meet the alarm annunciation
requirements.

2.09 SOFTWARE OVERVIEW

A. Dynamic Colored Floor plans: Dynamic colored floor plans that compare actual space conditions to setpoints shall be provided on all floorplan graphics displayed on the front-end. Floorplan enlargements shall also use the thermographs to display space conditions. Zones within the set point range shall appear transparent white. As the space gets warmer the zone color shall gradually modulate from transparent white to transparent red to identify a hot zone. As the space conditions get cooler the zone color shall gradually modulate from transparent white to transparent blue to identify a cold zone. Each zone shall indicate the current actual zone temperature within the zone. The floor plans shall use a dynamic scheduling icon to indicate schedule occupancy for each zone and provide direct one-click access to that zones unique schedule. Provide a designated icon or symbol indicating that the zone is in the occupied/unoccupied condition. From the floorplan graphic, the operator shall be able to click on any zone and go directly to the graphic for the piece of equipment controlling that zone. All dynamic floor plans shall be visible via web interface as well as on the LAN. The authorized system operator shall be able to change the zone or system identifier (or name) on the graphic and that change shall be distributed to other associated graphics and to the equipment controller.

B. Pop up Trends: Provide trend logs that automatically pop up when the operator mouse clicks on the point from the graphic. Provide pop up trends for all dampers, control valves, temperature sensors, carbon dioxide sensors, humidity sensors, airflow, static pressures, flow meters, VFD speeds, etc. The EMCS contractor shall set up all trends for the owner. The pop-up trend shall include a trend tool that allows the operator to modify the trend time scale and sample interval for up to 10 sample values. The trends shall be graphical on the computer screen but shall provide an output as an .xls, .csv, .pdf, HTML, r text file.

C. Interactive Maps: Implement JAVA SCRIPT API 3.0 or newer, such as Google Interactive maps depicting the facility location to indicate the site plan. This is not a static image and must be completely interactive.

D. Custom User HTML applications: The EMCS shall utilize HTML applications as an extra feature. At minimum, provide 7-day forecast, weather radar, traffic map and hurricane tracker. All of these features shall be imbedded into the EMCS system.

E. Provided a web-based EMCS platform; contractor shall provide an Open License software. Licenses that are not open are not acceptable. There shall be no per seat or per user licensing fee charged to the owner by the contractor.

F. System shall use the BACnet protocol for communication to the operator workstation or web server and for communication between control modules. Schedules, setpoints, trends, and alarms shall be BACnet Objects.

G. User access shall include 50 assigned operators that shall include five levels of access within the web system. Each operator log-in shall have an expiration date to allow for temporary access to the system. The operator's access description shall include his e-mail address and cell/phone numbers. The operator access can be limited from 5 minutes to permanent access. The user shall be limited to eight bad login attempts before being locked out of the system.

H. Global modification: Provide the capability for global modification of user definable parameters of all points shall be provided. Global modification is defined as the mass adjustment of user definable parameters across a defined group, area, facility, campus, or network. Parameters shall include, but not be limited to temperature set point (VAV boxes, AHU Discharge, VAV AHU Static Pressure Setpoints etc.), equipment start/stop, equipment status, valve output signal, VFD speed control signal, and damper position signal. User shall be able to lock the definable parameter to a set value, or adjust a set point to an operator adjustable value. This function shall be accomplished through the standard graphical user interface/workstation and is to be selectively applicable by the user to all controllers on the network, all controllers in a specific facility or all controllers in a specific zone within a specific facility.

I. The system operator shall be able to override the output signal to the valves, dampers, variable frequency drives, etc. with the use of the PC mouse click on the device. The system override shall include a Hand-Off-Auto (HOA) capability. If the output is commanded to the hand position the operator shall designate an output value of 0-100% in
2.10 ENERGY SAVING PROGRAMS

A. Duty Cycling: Periodically stop and start loads, based on space temperature, and according to various on/off patterns.

B. Automatic Time Scheduling: Self-contained programs for automatic start/stop/scheduling of building loads. Support up to seven (7) normal day schedules, seven (7) "special day" schedules and two (2) temporary schedules.

C. Optimal Start/Stop: Perform optimized start/stop as function of outside conditions, inside conditions, or both. Optimization shall be adaptive and self-tuning, adjusting to changing conditions by modifying occupancy period based upon the desired temperature at beginning and end of the occupancy period. Base optimization on occupancy schedules, outside air temperature, seasonal requirements, and interior room temperature. Employ adaptive model prediction for how long building takes to warm up or cool down under different conditions.

D. Night-Setback Program: Reduce heating space temperature setpoint or raise cooling space temperature setpoint during unoccupied hours in conjunction with scheduled start/stop and optimum start/stop programs.

E. Setpoint Reset: Setpoints for control of variable load systems shall be reset based on load demand, as described in the Sequence of Operations.

F. Calculated Points: Define calculations and totals computed from monitored points (analog/digital points), constants, or other calculated points.

G. Event Initiated Programming: Any data point capable of initiating event, causing series of controls in a sequence.

H. Holiday Scheduling

I. Direct Digital Control: Furnish software so operator is capable of customizing control strategies and sequences of operation by defining appropriate control loop algorithms and choosing optimum loop parameters.

J. Trend logging shall be provided for all points per the input/output summary where there is a change in the analog or binary signal. Each controller shall be capable of storing trend values and then automatically transfer data to the NAC or the NS hard disk. Trend data shall be updated continuously per the operator assigned interval at intervals as low as one minute. Collect samples at intervals specified in minutes, hours, days, or month. Output trend logs as line-graphs or bar graphs. Binary points (input and output) shall only be logged upon a change of value (COV). Display trend samples on workstation in graphic format. Automatically scale trend graph with minimum 60 samples of data in plot of time versus data.
2.11 FIELD INSTRUMENTATION

A. Temperature Sensors: All temperature sensors shall be thermistor type, factory-calibrated to within 0.5 °F, interchangeable with housing appropriate for application. Sensors shall have a temperature curve rated for the application. Sensor wiring terminations shall be in a galvanized box.
   1. Outside air temperature sensors shall be installed in weather proof enclosure with ventilated sun-shied
   2. Duct mounted temperature sensors shall be averaging type for supply air, mixed air and low temperature applications for air handling units. Duct probe temperature sensor shall be acceptable for terminal units.
   3. Space temperature sensors shall contain a backlit LCD digital display and user function keys along with temperature sensor, setpoint adjustment and after-hours override use. Override time may be set in one-hour increments.
   4. Thermowell temperature sensors shall be stainless steel probe of length that is equivalent to a minimum of 50% of the pipe diameter. End-to-end accuracy shall be ±0.5 deg. F. Connection box shall be moisture/water proof with conduit fitting. Furnish the stainless steel thermowell to the mechanical contractor for installation. A thermal conducting grease shall be installed in the thermowell to provide uniform temperature sensing.
   5. Provide flat plate stainless steel space temperature sensors with no local setpoint adjustment as indicated on the drawings.

B. Carbon Dioxide Sensors: The sensor shall be capable of monitoring carbon dioxide concentration with an accuracy of +/- 30 parts per million (PPM). The sensor shall produce a linear 0-10 VDC or 4-20 mA signal over the range of 0 to 2000 PPM. The sensor shall measure using non-dispersed infrared (NDIR) technology to measure carbon dioxide gas and shall be:
   1. Wall mounted carbon dioxide sensors shall be Veris CWE series or equivalent.
   2. Duct mounted carbon dioxide sensor shall be Veris CWD series or equivalent.
   3. The EMCS contractor shall utilize the required calibration devices to properly commission and calibrate the sensors per the manufacturer’s requirements.

C. Relative Humidity Sensors: relative humidity sensors shall be a two-wire type, 4-20 mA output proportional to the relative humidity range of 0-100%. The accuracy of the sensors shall be +/-2% over a range of 10-90% RH.
   1. Outdoor relative humidity sensors: provide non-corroding outdoor shield to minimize wind effects and solar heating. Install wall-mount weather proof enclosure with conduit fitting. Sensor shall be Veris HO series, or equivalent.
   2. Wall-mounted relative humidity sensor: sensor shall be installed in a wall-mounted enclosure with white cover. Sensor shall be Veris HEW series or equivalent.
   3. Duct-mounted relative humidity sensor: sensor shall be provided with a moisture resistant enclosure with conduit fitting. The probe length shall be 8” minimum. Sensor shall be Veris HED series or equivalent.

D. Pressure Transducers:
   1. Air pressure sensor: The pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA, The accuracy shall be +/- 0.25% FS. Sensor shall be SETRA Model 264 or equivalent.
   2. Water pressure sensors: The pressure sensors shall have an input range compatible with the medium being measured. The proportional output signal shall be 0-10 VDC or 4-20 mA. The accuracy shall be +/- 0.25% FS. Sensor shall be SETRA Model 230 or equivalent. Sensor shall be installed with a valved piping bypass and bleed off for each port.

E. Freezestat: Provide freezestats for all chilled water air handling systems that receive more than 10% untreated outside air. Freezestats shall provide vapor tension elements, which shall serpentine the inlet face on all coils. Provide additional sensors, wired in series, to provide one linear foot per square foot of coil surface area. Freezestat shall be manually reset at the switch. Interlock to the associated fan so that fan will shut down when HOA switch is in hand or auto position. Provide time delay relays with a 0-10 minute time delay relay duration to minimize nuisance freezestat trips. Time delay relay shall be adjustable at the associated control panel.
F. Air differential pressure switch: For fan shutdown, provide air differential pressure switches for all fans controlled by a variable frequency drive (VFD) to shut down the associated fan in the event of sensing high differential pressure. Air differential pressure switches shall have an adjustable setpoint with a range of 0-10 inches w.g. with manual reset at the switch. Provide ¼ inch copper tubing with compression fittings to mount to the side of the duct. Sensor shall be DWYER Series 1900 or equivalent.

G. Momentary control relays: Provide momentary control relays as indicated. Relays shall have coil ratings of 120 VAC, 50 mA or 10-30 VAC/VDC, 40 mA as suitable for the application. Contact ratings shall be 10 amp. Provide complete isolation between the control circuit and the digital output. Relays shall be located in the UC or other local enclosures and have pin-type terminals. Relays shall have LED indication of status.

H. Current sensing relay: Current sensing relays shall be rated for the applicable load. The output relay shall have an accessible trip adjustment over its complete operating range. Enclosure shall have an LED to indicate relay status.

I. Photocell: Ambient light level shall by a photocell in a non-corroding in a weatherproof housing with sun shield suitable for exterior installation. The control signal output shall be 4-20 ma or binary contact closure as specified in the sequences of operation. Mount the photocell on the north side of the building on the roof. The sensor reading shall be 0-750 foot-candles.

J. Occupancy Sensors
1. The dual-technology occupancy ceiling mounted sensor shall be capable of detecting presence in the control area by via Doppler shifts in transmitted ultrasound and passive infrared (PIR) heat changes. Sensor shall utilize Dual Sensing Verification Principle for coordination between ultrasonic and PIR technologies. Detection verification of both technologies must occur in order to activate lighting systems. Sensor shall have a retrigger feature in which detection by either technology shall retrigger the lighting system on within 5 seconds of being switched off. The sensor shall operate at 24 VDC/VAC. WattStopper DT-300 or approved equal.
2. Sensors shall have a time delay that is adjustable with configuration software or shall have a fixed time delay of 5 to 30 minutes, set by a DIP switch. Sensors shall feature a walk-through mode, where lights turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
3. The sensor shall have an additional single-pole, double throw isolated relay with normally open, normally closed and common outputs. The isolated relay is for use with HVAC control, data logging, and other control options. The sensor shall have an LED indicator that remains active at all times in order to verify detection within the area to be controlled.

2.12 WATER FLOW METERS
A. Insertion Electromagnetic Flow Meters shall be provided where indicated on mechanical drawings or in control diagrams in piping larger than 1 inch. The flow meter shall have a 316L stainless steel insertion probe with XAREC sensor head and weather-tight NEMA 4 electronics enclosure; +/- 1.0 % accuracy of actual reading from 2 to 20 ft/s and +/- 0.02 ft/s below 2 ft/s; flow range of 0.1 ft/s to 20 ft/s, turndown ratio of 200:1; pulse outputs proportional to flow rate. The flow meter shall be installed with a minimum of 10 diameters of straight pipe upstream and 5 diameters of straight pipe downstream. Refer to meter manufacturer's installation manual for additional straight pipe length requirements. Provide full port valve to allow for removal and re-insertion without disruption to the water service, to be installed by Division 23. Meter shall be ONICON F-3500 series or pre-approved substitution.

B. Inline nutating-disk type flow meters shall be provided for domestic water and cooling tower metering applications. The meter shall include a pulse output for monitoring by the EMCS. Provide meter to be installed by Division 23. Meter shall be Badger RCDL series or approved substitution.

2.13 AIRFLOW MEASURING STATIONS (AFMS)
A. Duct mounted airflow measuring stations with combination airflow and air temperature measurement devices shall have the following features:
1. Multi-point sensors in one or more probe assemblies with a maximum of one to sixteen sensor nodes per location, and a single remotely mounted microprocessor-
based transmitter for each measurement location. Each sensor node shall consist of two hermetically sealed bead-in-glass thermistors. Each sensing point shall independently determine the airflow rate and temperature at each node, which shall be equally weighted in calculations by the transmitter prior to output as the cross-sectional average. Each ducted sensor probe shall have an integral, U.L. Listed, plenum rated cable. Each independent temperature sensor shall have a calibrated accuracy of +/-0.14°F (0.08°C) over the entire operating temperature range of -20°F to 160°F (-28.9°C to 71°C) and shall be calibrated at 3 temperatures against standards that are traceable to NIST. Acceptable manufacturer shall be EBTRON, Inc. GTx116-PC.

2. Each transmitter shall have a display capable of simultaneously displaying both airflow and temperature. Airflow rate shall be field configurable to be displayed as velocity or volumetric rates, selectable as IP or SI units. Each transmitter shall operate on 24 VAC and be fused and protected from over voltage, over current and power surges.

3. Each independent airflow sensor shall have a laboratory accuracy of +/-2% of Reading over the entire calibrated airflow range of 0 to 5,000 fpm (25.4 m/s) and shall be wind tunnel calibrated at 16 points against air velocity standards that are traceable to NIST.

2.14 DAMPERS:
A. Provide motorized volume control and shutoff dampers as detailed in 23 33 00 Ductwork Accessories.

2.15 DAMPER ACTUATORS:
A. Outside and exhaust air damper actuators shall be mechanical spring return. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
B. Outside and return air modulating actuators shall utilize analog (proportional) control 0-10 VDC. Actuators shall be driven in both the open and closed directions.
C. Electric damper actuators shall be direct shaft mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or setscrew type fasteners are not acceptable.
D. Single section dampers shall have one electronic actuator direct shaft mounted.
E. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per damper section.
F. Damper actuators shall be BELIMO or equivalent.

2.16 CONTROL VALVES
A. Furnish all valves controlled by the EMCS as shown on the Mechanical Drawings. Furnish all automated isolation valves as shown on the Mechanical Drawings. Control valves shall be factory fabricated of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated. EMCS contractor to size control valve with a maximum of 3 psi pressure drop. 2-position isolation valves shall be full-line size.
1. All chilled water, condenser water, and hot water valves shall meet, at minimum, the following ANSI Class 150 ratings. Valves 0.5 inch to 2 inches shall have NPT female screwed ends. Valves 2.5 inches and larger shall have flanged ends.
2. Equal Percentage control characteristic shall be provided for all water coil control valves.
B. Pressure Independent Characterized Control Ball Valves ½” to 6”, for two-way modulating applications shall have equal percentage characteristics and control the flow from 0 to 100% full rated flow with an operating pressure differential range of 5 to 50 PSI across the valve. The pressure independent control valve shall be provided and delivered from a single manufacturer as a complete assembly. The actuator shall be integrally mounted to the valve at the factory with a single screw on a direct coupled DIN mounting-base. All valve actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow and/or temperature control. Programming using actuator mounted switches or multi-turn actuators are not acceptable. The control valves shall be sized for the scheduled flow and not pressure drop. Calibrated Balancing Valves and Automatic Flow-Control Valves shall be
prohibited from use at coil circuit piping where pressure independent control valves are installed. Contractor shall provide a section of straight pipe five times the pipe diameter with respect to the nominal valve size upstream of the control valve assembly where utilizing integral flow sensor to guarantee sensor accuracy.

1. NPS 3/4” and Smaller: Belimo PIQCV or equal. Forged brass body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, characterizing disc integral to ball, PTFE ball seat, dual EPDM lubricated O-rings, and female NPT union ends. Close off pressure rating of 100 psi. Integral pressure regulator located upstream of ball to maintain a constant pressure differential. Replaceable cartridge type regulators are not permitted.

2. NPS 1” through 2”: Belimo ePIV or equal. Forged brass, nickel-plated body rated at no less than 360 PSI, stainless steel ball and blowout-proof stem, PTFE ball seat, dual EPDM lubricated O-rings, stainless steel or TEFZEL characterizing disc, and female NPT union ends. Close off pressure rating of 200 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.

3. NPS 2-1/2” through 6”: Belimo ePIV or equal. GG25 cast iron body according to ANSI 125, Class B, stainless steel ball and blowout-proof stem, PTFE ball seat, with a dual EPDM lubricated O-rings and a stainless steel flow characterizing disc. End connection pattern to match ANSI 125 flange. Close off pressure rating of 100 psi. Valve shall be integrated with an electronic (ultra-sonic or electromagnetic) flow sensor (accuracy +/- 2%) providing analog flow feedback. The valve shall reposition to maintain the required flow with a +/- 5% accuracy over a pressure differential range of 1 to 50 psi.

C. Characterized Control Ball Valves (CCV) for ½” to 2”: for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo or approved equal.

1. Valve housing shall consist of forged brass rated at no less than 400 psi at 250 °F. Three-way valves shall have EPDM O-rings behind ball seats to allow for a minimum close-off pressure of 40 psi with an actuator that provides 35 in-lbs torque for ½ to 2 in. sizes. Three-way valves shall be installed in a “tee” configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.

D. Globe Valves 2-1/2” to 6”: for 3-way modulating applications shall have equal percentage characteristics. Manufacturer shall be Belimo G7 series or approved equal.

1. Valve housing shall consist of cast iron rated at no less than 125 psi at 300 °F. Valve shall have stainless steel stem, plug and seat. Three-way valves shall be installed in a “tee” configuration with actuator perpendicular to the shaft. Confirm mixing or diverting application for correct valve selection.

E. Butterfly valves: For chiller and cooling tower isolation control valves, butterfly control valves may be provided.

1. Butterfly Isolation valves shall be line-size. Design velocity shall be less than 12 feet per second when used with standard EPDM seats. Butterfly valves shall have ductile iron body, 304 stainless steel disc and EPDM seat. The valve body close-off pressure rating shall be 150 psi over a range of -20 F to 250 F. The flange shall be ANSI 125/250. Belimo F6 and F7 series or approved manufacturer.

F. Actuators for characterized control valves and globe valves: Provide electric actuators for all control valves that are furnished as part of the EMCS contract. Two-way and three-way control valve actuators shall meet, at minimum, the following requirements:

1. Motor driven type with gear assembly made of hardened steel. Actuator shall have an input voltage of 24 VAC. Provide visual mechanical position indication.

2. Actuators installed within the interior of the building envelope shall be provided with NEMA-2 rated housings.

3. Actuators installed exterior to the building envelope shall be provided with NEMA-4 rated housings or a weather shield. All penetrations through exterior actuator housings shall be provided with fittings that prevent water ingress.

4. Valves shall be sized to meet the shut-off requirements when operating at the maximum system differential pressure and with the installed system pump operating at shut-off head. Actuators shall control against system maximum working pressures.
5. Normal and failure positions shall be as indicated in the operating sequences. Provide spring return action per the sequences.
6. Manual declutch lever to enable manual operation of the valve. It shall be possible for an operator to manually modulate valves located in mechanical rooms in the event of loss of power.
7. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
8. All actuators shall be capable of being electronically programmed in the field by use of external computer software or a dedicated handheld tool for the adjustment of flow. Programming using actuator mounted switches or multi-turn actuators are not acceptable.
9. Electric actuators shall be Belimo, compatible with the valves furnished.

G. Butterfly Valve Industrial Actuators
1. Enclosure shall be NEMA 4 (weatherproof) enclosure and will have an industrial quality coating.
2. Actuator shall have a motor rated for continuous duty. The motor shall be fractional horsepower; permanent split capacitor type designed to operate on a 120 VAC, 1 phase, 60 Hz supply. Two adjustable cam actuated end travel limit switches shall be provided to control direction of travel. A self-resetting thermal switch shall be imbedded in the motor for overload protection.
3. Reduction gearing shall be designed to withstand the actual motor stall torque. Gears shall be hardened alloy steel, permanently lubricated. A self-locking gear assembly or a brake shall be supplied.
4. Actuator shall have a 6 ft wiring harness provided for ease in field wiring (above 1500 in-lbs). Two adjustable SPDT cam-actuated auxiliary switches, rated at 250 VAC shall be provided for indication of open and closed position. Actuator shall have heater and thermostat to minimize condensation within the actuator housing.
5. Actuator shall be equipped with a hand wheel for manual override to permit operation of the valve in the event of electrical power failure or system malfunction. Hand wheel must be permanently attached to the actuator and when in manual operation electrical power to the actuator will be permanently interrupted. The hand wheel will not rotate while the actuator is electrically driven.
6. The actuator shall be analog, floating, or two position as called out in the control sequence of operation. All analog valves shall be positive positioning, and respond to a 2-10 VDC, 4-20 mA, or adjustable signal as required. Analog actuators shall have a digital control card allowing any voltage input for control and any DC voltage feedback signal for position indication.
7. Butterfly valve actuators shall be Belimo furnished with specified butterfly valves.

2.17 PANELS AND ENCLOSURES
A. Provide panels and enclosures for all components of the EMCS, which are susceptible to physical or environmental damage.
B. Interior panels and enclosures shall meet be NEMA 1 rated painted steel panels with locking door.
C. Exterior mounted panels and enclosures shall be NEMA 4 painted steel panels with locking door.
D. Panels for USCs shall be mounted on the outside of all unit ventilators and fan coil units with three feet of wall clearance in front of them and no higher than 7 feet to the bottom of the panel.

2.18 LABELING AND WARNING NOTICES
A. Provide labeling for all control panels and enclosures.
B. Provide labeling of all control wires and input/output points at the controller and at the control device; the label at each end of the wire shall be the same. Labels shall be machine generated, typed and clearly legible with a maximum of 17 characters. Hand written labels or labels written on the control wire jacket will not be acceptable. Each label shall be unique to its function and shall reference the applicable system. For example "AHU-1 SAT"
will indicate the supply air temperature sensor for AHU-1. Improper labeling shall be removed and shall require re-commissioning of the control device and controller to document correct functionality.

C. Provide high voltage warning notices at all equipment controlled by the EMCS and at all associated motor starters when used by equipment controller.

2.19 TUBING AND PIPING
A. Provide tubing and piping as required for the field instrumentation.
B. Tubing within equipment rooms, vertical risers, and penetrations to ductwork shall be either copper pipe or shall be plastic tubing within conduit. Tubing for all water-based instrumentation shall be copper pipe. Identify the type of tubing proposed in the shop drawing submittal.
C. Provide suitable bulk head fittings for duct and panel penetrations.
D. Tubing in plenum rated areas may be plastic tubing. Polyethylene tubing shall meet, at minimum, the following requirements: flame retardant; crack resistant; 300 psi burst pressure.

2.20 CONDUIT AND FITTINGS
A. Provide all conduits, raceways and fittings for the EMCS monitoring, communication and control cabling. All work shall meet all applicable codes.
B. Conduit, where required, shall meet, the requirements specified within Division 26.
C. EMCS monitoring and control cable shall not share conduit with cable carrying voltages in excess of 90 VAC.

2.21 CABLELING
A. Provide all cables for the EMCS. Cable shall meet, at minimum, the following requirements:
   1. Minimum 98% conductivity stranded copper.
   2. Proper impedance for the application as recommended by the EMCS component manufacturer.
   3. Monitoring and control cable shall be #18 AWG or larger, dependent on the application. Analog input and output cabling shall be shielded.
   4. Management Level Network cable shall be CAT 6, 24 gauge unshielded.
   5. Automation Level Network cable shall be #24 AWG shielded.
   6. Shield shall be grounded at the CCP, UC, or control panel. Ground at one end only to avoid ground loops.
   7. Identification of each end at the termination point. Identification should be indicated on and correspond to the record drawings.
B. 120 VAC power wiring shall be of #12 AWG solid conductor or larger as required.

PART 3 - EXECUTION
3.01 PRE-CONSTRUCTION
A. The EMCS supplier shall provide a pre-construction coordination meeting with the affected trades to ensure a cooperative efficient process of installation. The invited trades shall include the general contractor, mechanical contractor, electrical contractor, test and balance contractor, owner's representative, consulting engineer and others with a direct interest in the coordination of the affected systems. The EMCS contractor shall provide an outline of the meeting agenda highlighting the construction schedule, coordination with mechanical and electrical trades. Provide a sign-in sheet and submit it through the attendees along with a summary of the meeting notes for future reference.

3.02 INSPECTION DURING INSTALLATION
A. Provide a technician to assist the Engineer or Owner's Representative with inspections made during the installation period that are required to review the progress and quality of ongoing work. The engineer/owner’s representative shall generate field observation reports on the findings of the inspection. The engineer or owner’s representative shall advise the EMCS contractor during the inspection of any concerns noted with respect to the installation and shall repeat the concerns in writing as soon as possible after the inspection is completed. The EMCS contractor shall take corrective action to meet the requirements of the specifications. Upon correction, the EMCS contractor shall submit written documentation through the contractors to the engineer.
3.03 INSTALLATION OF COMPONENTS

A. Provide all interlock and control wiring. All wiring shall be installed in a neat and professional manner in accordance with specification Division 26 and all national, state and local electrical codes.

B. Provide wire and wiring techniques recommended by equipment manufacturers. Control wiring shall not be installed in power circuit raceways. Magnetic starters and disconnect switches shall not be used as junction boxes. Provide auxiliary junction boxes as required. Coordinate location and arrangement of all control equipment with the Owner's Representative prior to rough-in. Provide auxiliary pilot duty relays on motor starters as required for control function.

C. Electrical Contractor shall provide 120 or 277 volt power at a junction box within 48” of the controller. The BAS Contractor shall coordinate with the Electrical Contractor to identify locations of power requirements prior to the installation of the controls.

D. Conduit for control wiring shall be provided whenever one of the following conditions exists:
   1. Conduit is indicated on the drawings or specifically required by the specifications.
   2. Cabling runs through inaccessible areas such as within partitions/walls, above closed in ceilings, under floor; within trenches and underground; on the exterior of the building; exposed on the surface of the building; when encased in concrete or other material that makes the cable inaccessible or when located such that access to the cable is not readily obtained.
   3. Cable within mechanical, telecommunications and electrical equipment rooms and control rooms.
   4. Conduit shall be installed, inside wall from sensor box to above the wall, for all wall mounted temperature, humidity and CO2 sensors.

E. Control wiring located above an accessible ceiling space may be plenum rated cable. Plenum rated wire shall be bundled and routed at right angles to the building lines and secured to the building structure every 15 feet.

F. Control wiring located in underground conduits shall be provided with direct-burial-rated insulation.

G. When communication bus enters or exits a building, a surge suppressor shall be installed. The surge suppressor shall be installed according to the controls manufacturer’s instructions.

H. Provide sleeves for all cable and conduit passing through walls, partitions, structural components, floors and roof

I. All sensor wiring shall be labeled to indicate the origination (at the device) and destination of data (at the control panel). The description shall indicate the type and location of the control device such as “AHU-1 SA temp” or “VAV 1-1 space temp”.

J. Wall temp sensors at 48’ above the finished floor to comply with ADA requirements and to match the height of the light switches. Mount humidity sensor at equal height to wall temperature sensor.

3.04 VERIFICATION REQUIREMENTS

A. Verification shall be provided by the EMCS contractor to demonstrate and confirm that the installed system complies with the specifications and the control sequences of operation herein specified. Upon completion of the verification process the EMCS contractor shall demonstrate to the engineer or owner’s representative the functionality of the control system devices are in compliance with the contract documents.

B. Technicians provided by the EMCS contractor shall be factory trained and qualified in the operation of the provided control system. The EMCS contractor shall provide, if requested, the factory training certificates of the individuals providing the verification services on this project.

C. Verification tools, applicable to the system provided, shall be utilized by the factory-trained technicians for proper verification of system operation and functionality. Temperature verification sensors shall be NIST certified within the last 12 months. Meters such as Fluke 52 series or better shall be utilized. Use of non-certified meters may require the system to be re-verified with certified meters at no cost to the owner.
D. Documentation of the verification process shall be provided per the project general conditions in electronic PDF format as required. Documentation shall include the following forms:

1. Project System Verification Forms for each controller provided on the project to verify the proper function of each controller, control device and system component provided.
2. Panel Verification Forms for each control panel to document the proper installation and function of each control panel provided.
3. Sequence of Operation Verification Forms for each piece of controlled equipment to confirm compliance of the control system with the specified sequences of operation.
4. Not providing proper documentation for each control devices, panel, or system, upon request by the engineer or owner’s representative, may require the EMCS contractor to re-verify the applicable systems at no additional cost to the owner.

E. After completion of the verification, the EMCS contractor shall be able to demonstrate the sequence of operations for each system to the engineer and the owner’s representative.

F. Equipment checkout sheets are to be produced by this contractor showing checkboxes and compliance with the following procedures for each piece of equipment and turned over to the owner and/or mechanical engineer.

3.05 COLORGRAPHICS

A. The colorgraphics shall be provided for the EMCS system prior to system acceptance and owner training.

B. The colorgraphics provided shall include the following as a template. Provide forward and backward links on the graphic.

1. Site plan with link to overall building plan including detached buildings. The site plan shall be referenced to an automatically updated aerial view or map view of the area such as Google Maps or Bing Maps. Provide link to proceed to the overall building floor plan.
2. The overall building plan shall indicate space temperature conditions referenced by the color of the zone. Specific details of the zone temperatures and equipment are not required. Provide a link to the floor plan wings, upper floors and remote buildings.
3. The floor plan colorgraphics shall indicate the space temperatures by color references. Additional information shall indicate the space temperature, the occupancy of the zone, air handling units, VAV terminals and ductwork with diffusers. A link at each terminal unit or AHU shall automatically connect the system operator to the equipment colorgraphic.
4. The colorgraphics for the equipment shall as a minimum be equal to the points from the input/output summary or control schematic. Primary control devices as required by the sequences of operation shall also be provided.
5. Control points from equipment that are integrated into the EMCS via BACnet shall be provided to convey the operating conditions of the attached equipment. Coordination of the integration points shall be accomplished during the submittal phase. The EMCS contractor shall provide a list of all integrated points on their submittal.

3.06 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. Startup testing documentation: Prepare the checklist documenting startup testing of each input and output device, with technician's initials and date certifying each device has been tested and calibrated prior to acceptance testing. This document shall indicate proof that the following functions have been commissioned and shall be included in the as-built documentation: short to ground check, configuration of trends, confirmation that colorgraphics are accurately representing actual systems, point to point checkout, all damper and valve actuators respond to input change, control modules are addressed and have functional descriptors, specified interlocks are functional, calibration report of all sensors, discrete outputs respond to time schedule or manual enable command.

B. Demonstration. Prior to acceptance, demonstrate the following performance tests to demonstrate system operation and compliance with specifications.

1. Engineer, owner’s representative and mechanical contractor shall be invited to observe and review system demonstration. Provide attendees at least 10 days notice.
2. Demonstration shall follow process approved as part of the submittal and shall include complete checklists and forms for each system as part of system demonstration.
3. Demonstrate actual field operation of each sequence of operation as specified. Demonstrate calibration and response of any input and output points requested by engineer or owner's representative.

4. Demonstrate complete operation of operator interface including review of color-graphics, time schedules, trend logs, alarm notification, functionality of tablet PC operation.
   a. PID loop response. Supply graphical trend data output showing each PID loop's response to a set point change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be selectable from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show set point, actuator position, and controlled variable values.
   b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand limiting setpoint, and status of set points and other affected equipment parameters.
   c. Trend logs for each system. Trend data shall indicate set points, operating points, valve positions, and other data as specified. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.

5. Alarms and Interlocks. Check each alarm with an appropriate signal at a value that will trip the alarm. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction. Alarm verification shall include temperatures exceeding alarm threshold (high and low), fan failure safety, duct high static pressure switch, freezestat, and smoke detector shutdown.

6. Tests that fail to demonstrate proper system operation to the engineer shall be repeated after contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

C. Owner Acceptance.
   1. After tests described in this specification are performed to the satisfaction of both engineer and owner's representative, the engineer shall accept the control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond EMCS contractor's control. Engineer shall provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
   2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved by the engineer.

3.07 DEMONSTRATION AND OWNER TRAINING
   A. Furnish basic operator training for multiple persons on data display, alarm and status descriptors, requesting data, execution commands and log requests. Include a minimum of 16 hours: 8 hours instructor time for onsite training and 8 hours of hands on class environment training. Training sessions may be provided in 4-hour increments as approved by the owner's representative.
      2. Change/modify time of day, holiday and override schedules.
      3. Display, create, and modify trends of system points.
      4. Update room numbers on the color-graphics.

   B. Demonstrate complete and operating system to Owner. Provide written documentation listing the attendees of the specified training with sign-in sheet and training time and date.

3.08 SEQUENCE OF OPERATIONS
   A. Refer to the Mechanical Drawings for project control schematics and sequence of operations.

END OF SECTION
SECTION 23 21 13

ABOVE GROUND HYDRONIC PIPING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED

A. Pipe and pipe fittings.

B. Valves.

C. Heating water piping system.

D. Chilled water piping system.

E. Condensate drain piping.

1.03 RELATED WORK

A. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping

B. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC

C. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment

D. Section 23 05 53 - Identification for HVAC Piping and Equipment

E. Section 23 07 19 - HVAC Piping Insulation

F. Section 23 21 16 - Underground Hydronic Piping

G. Section 23 21 19 - Hydronic Specialties

1.04 REFERENCES

A. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.

B. ASME B31.1 - Power Piping.

C. ASME B31.3 - Process Piping.

D. ASME B31.9 - Building Services Piping.

E. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications.


J. AWS D1.1/D1.1M - Structural Welding Code - Steel.


M. ASTM B32 - Solder Metal.

N. ASTM B88 - Seamless Copper Water Tube.

1.05 QUALITY ASSURANCE

A. Foreign made pipes, valves and fittings will not be acceptable.
B. Valves: Manufacturer's name and pressure rating marked on valve body.
C. Welding Materials and Procedures: Conform to ASME BPVC-IX and applicable state labor regulations.
D. Welder’s Certification: In accordance with ASME BPVC-IX.

1.06 SUBMITTALS
A. Submit product data under provisions of Division One.
B. Include data on pipe materials, pipe fittings, valves, and accessories.
C. Include welder’s certification of compliance with ASME BPVC-IX.

1.07 DELIVERY, STORAGE, AND HANDLING
A. Deliver products to site under provisions of Division One.
B. Store and protect products under provisions of Division One.
C. Deliver and store valves in shipping containers with labeling in place.
D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
E. Protect piping systems from entry of foreign materials by temporary covers, proper storage and dunnage, completing sections of the work, and isolating parts of completed system. Tape will not be allowed as an acceptable end cover.

PART 2 - PRODUCTS

2.01 CHILLED AND HEATING WATER [<>] PIPING
A. Steel Pipe: ASTM A53/A53M, Schedule 40, 0.375 inch wall for sizes 12 inch and over, black.

2.02 CONDENSER WATER PIPING
A. Steel Pipe: ASTM A53/A53M, Schedule 40, 0.375 inch wall for sizes 12 inch and over, black
   2. Joints: Screwed, or AWS D1.1/D1.1M welded.

2.03 EQUIPMENT DRAINS AND OVERFLOWS
A. Steel Pipe: ASTM A53/A53M, Schedule 40 galvanized.
   1. Fittings: Galvanized cast iron, or ASME B16.3 malleable iron.
   2. Joints: Screwed, or grooved mechanical couplings.

2.04 FLANGES, UNIONS, AND COUPLINGS
A. Pipe Size 2 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
B. Pipe Size Over 2 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; 1/16 inch thick preformed neoprene bonded gasket.
C. Grooved mechanical pipe couplings, fittings, valves and other grooved components may be used as an option to welding, threading or flanged methods. All grooved components shall be of one manufacturer, and conform to local code approval and/or is listed by ASME B31.1, ASME B31.3, ASME B31.9, ASME, UL/ULC. FM, IAPMO or BOCA. Grooved end manufacturer to be ISO-9001 certified. Grooved couplings shall meet the requirements of ASTM F1476. Manufacturer shall be Victaulic or approved equal. Can be utilized only in mechanical rooms or cooling tower areas.

2.05 ACCEPTABLE MANUFACTURERS - GLOBE VALVES
A. Milwaukee.
B. Nibco.
C. Stockham.
D. Dezurik.

2.06 GLOBE VALVES
A. Up to 2 Inches: Bronze body, bronze trim, rising stem and handwheel, inside screw, renewable stainless steel disc, screwed ends, with back seating capacity.
B. Over 2 Inches: Iron body, bronze trim, rising stem, hand wheel, OS&Y, plug-type disc, flanged ends, renewable seat and disc.

2.07 ACCEPTABLE MANUFACTURERS - BALL VALVES
A. Milwaukee.
B. Nibco.
C. Jamesbury.
D. Dezurik.
E. IMI Flow Design.
F. Kitz.
G. Victaulic (For grooved systems only)

2.08 BALL VALVES
A. Up to 2 Inches: Bronze two-piece body, 600 PSI full port, stainless steel ball and stem, teflon seats and stuffing box ring, lever handle, and balancing stops, threaded ends.
B. Over 2 Inches: Cast steel body, chrome plated steel ball, teflon seat and stuffing box seals, lever handle, or gear drive hand wheel for sizes 10 inches (250 mm) and over, flanged.
C. Ball valves installed in insulated lines shall have stem extensions compatible with up to 2” of insulation. Extensions shall be non-metallic equal to Nibco “nib-seat”.

2.09 ACCEPTABLE MANUFACTURERS - PLUG COCKS
A. Nibco.
B. Jenkins.
C. Dezurik.
D. Milwaukee.

2.10 PLUG COCKS
A. Up to 2 Inches: Bronze body, bronze tapered plug, non-lubricated, teflon packing, threaded ends, with one wrench operator for every ten plug cocks.
B. Over 2 Inches: Cast iron body and plug, pressure lubricated, teflon packing, flanged ends, with wrench operator with set screw.

2.11 ACCEPTABLE MANUFACTURERS - BUTTERFLY VALVES
A. Fisher

2.12 BUTTERFLY VALVES
A. Stainless steel disc, resilient replaceable seat for service to 180 degrees F lug or grooved ends, extended neck, infinite position lever handle with memory stop. Hand wheel and gear driven where indicated. Valve shall be rated at full working pressure with downstream flange removed in either direction.

2.13 ACCEPTABLE MANUFACTURERS - SWING CHECK VALVES
A. Milwaukee.
B. Nibco.
C. Stockham.
D. Dezurik.
E. Victaulic (For grooved systems only)
F. Substitutions: Under provisions of Division One.

2.14 SWING CHECK VALVES
A. Up to 2 Inches: Bronze 45 degree swing disc, screwed ends.
B. Over 2 Inches Iron body, bronze trim, 45 degree swing disc, renewable disc and seat, flanged or grooved ends.

2.15 ACCEPTABLE MANUFACTURERS - SPRING LOADED CHECK VALVES

A. Milwaukee.
B. Nibco.
C. Mueller.
D. Dezurik.
E. Victaulic (For grooved systems only)
F. Substitutions: Under provisions of Division One.

2.16 SPRING LOADED CHECK VALVES

A. Iron body, bronze trim, stainless steel spring, aluminum bronze disc, screwed, grooved, wafer or flanged ends.

2.17 ACCEPTABLE MANUFACTURERS - RELIEF VALVES

A. Nibco.
B. Jenkins.
C. Dezurik.
D. Milwaukee.
E. Substitutions: Under provisions of Division One.

2.18 RELIEF VALVES

A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labeled.

PART 3 - EXECUTION

3.01 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt on inside and outside before assembly.
C. Prepare piping connections to equipment with flanges or unions.
D. After completion, fill, clean, and treat systems.
E. Provide extended necks for all vents, thermometer wells, pressure gauge wells, pet cocks and pete’s plugs.

3.02 INSTALLATION

A. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
B. Install piping to conserve building space, and not interfere with use of space and other work.
C. Group piping whenever practical at common elevations.
D. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment. Refer to Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping.
E. Provide clearance for installation of insulation, and access to valves and fittings.
F. Provide access where valves and fittings are not exposed. Coordinate size and location of access doors with Division 08.
G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
H. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
I. Prepare pipe, fittings, supports, and accessories for finish painting. Refer to Division 09.
J. Install valves with stems upright or horizontal, not inverted.
K. All grooved components (couplings, fittings, valves, gaskets, and specialties) shall be of one manufacturer.
L. Grooved manufacturer shall provide on-site training for contractor’s field personnel by a factory trained representative in the proper use of grooving tools, application of groove, and the product installation. Factory trained representative shall periodically visit the job site and inspect installation. Contractor shall remove and replace any improperly installed products.

3.03 APPLICATION
A. Use grooved mechanical couplings and fasteners only in mechanical rooms or cooling tower area.
B. Install unions downstream of valves, and at equipment or apparatus connections.
C. Install brass male adapters each side of valves in copper piped system. Sweat solder adapters to pipe.
D. Install ball valves for shut-off and to isolate equipment, part of systems, or vertical risers.
E. Install plug valves for throttling, bypass, or manual flow control services.
F. Provide spring loaded check valves on discharge of condenser and chilled water pumps.
G. Use plug cocks for throttling service. Use non-lubricated plug cocks only when shut-off or isolating valves are also provided.
H. Use only butterfly valves in condenser water systems for throttling and isolation service.
I. Use lug end butterfly valves to isolate equipment.
J. Provide chain operated butterfly valve for installations at 12 feet or higher.
K. Provide 3/4-inch ball (drain) valves equal to Nibco T-585-70-HC at main shut-off valves, low points of piping, bases of vertical risers, and at equipment and pipe to nearest drain.
L. Provide automatic air vents at all high points and air pockets in the system.

3.04 CONDENSATE DRAIN PIPING
A. Drain piping from each unit shall be extended to the nearest floor drain or condensate drainage system. Drains shall be of the size indicated but not less than the full size of the drain pan connections.
B. Use plugged tees in lieu of elbows.
C. Slope all drain lines 1/8” per foot, minimum.
D. Provide auxiliary drain pan on all AHU's above ceiling with auxiliary drain line routed to discharge in visually prominent area. Discharge location shall be coordinated with Architect.

3.05 PIPE FABRICATION AND INSTALLATION
A. All pipes shall be cut accurately to measurements established at the site and shall be worked into place without springing or forcing.
B. Piping layout and installation shall be made in the most advantageous manner possible with respect to headroom, valve access, opening and equipment clearance, and clearance from other work. Particular attention shall be given to piping in the vicinity of equipment; layout shall be made in such manner as to preserve maximum access to the various equipment parts for maintenance.
C. All changes in directions shall be made with fittings; field bending and mitering of pipe is prohibited.
D. Air vents and air chambers shall be installed as hereinafter specified.

3.06 OFFSETS AND FITTINGS
A. Due to the small scale of the Drawings, it is not possible to indicate all offsets, fittings, etc. which may be required. The Contractor shall carefully investigate structural and finish conditions affecting the Work, and shall take such steps as may be required to meet such conditions at no additional cost to the Owner.
B. All piping shall be installed close to walls, ceilings and columns, (consistent with the proper space for covering, removal of pipe and special clearances), so as to occupy the minimum
of space, and all offsets, fittings, etc., required shall be provided at no additional cost to the Owner.

3.07 SECURING AND SUPPORTING
A. All piping shall be adequately supported to line and grade, with due provisions for expansion and contraction.
B. Piping shall be supported on approved clevis type, split ring, or trapeze type hangers properly connected to the structural members of the building.
C. All insulated piping shall be fitted with suitable steel protection saddles.
D. Perforated bar hangers, straps, wire or chains will not be permitted.

3.08 ISOLATION VALVES
A. All piping systems shall be provided with line size shut-off valves located at risers, at branch connections to mains, and at other locations as indicated and required.

3.09 TESTING OF PIPING SYSTEMS
A. During the progress of the Work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Engineer. The Engineer or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.
B. Tests shall be conducted as part of this Work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
C. Tests shall be performed before piping of various systems have been covered or furred-in.
   For insulated piping systems, testing shall be accomplished prior to the application of any insulation.
D. All piping systems shall be tested and proved absolutely tight for a period of not less than 2 hours at a pressure of 150 psi(g) or 150% of design pressure, whichever is greater. Tests shall be witnessed by the Engineer or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks, damage, or defects.
F. Wherever conditions permit, each piping system shall thereafter be subjected to its normal operating pressure and temperature for a period of no less than five 5 days. During that period, it shall be kept under the most careful observation. The piping systems must demonstrate the propriety of their installation by remaining absolutely tight during this period.

3.10 PIPE CLEANING, FLUSHING AND PURGING REQUIREMENTS AND PROCEDURES
A. The hydronic system shall be flushed and purged by contractor:
   1. All mains, branches and zones shall be cleaned and treated per steps indicated below.
   2. Owner/Engineer shall be given 72-hour notice prior to each step being performed.
B. Pre-flush requirements: Purpose is to get system ready for flushing and purging:
   1. Piping must pass all required pressure testing and visual inspection for leaks.
   2. All pumps shall be tested for rotation and properly aligned and lubricated.
   3. Chemicals planning on being used must have certificate of assurance and product cut sheets presented to the owner/engineer prior to being used. All chemicals must be approved by the state prior to being added to the system, FDA approved and meet ASTM D1384. Automotive grade chemicals are not allowed.
   4. Bypass all terminal units and coils by connecting the supply and return piping together.
   5. Fill entire system with clean fresh potable water.
C. The flush requirements: Purpose is to completely remove all debris, dirt and air from hydronic system.
   1. Add system cleaner that contains detergent and emulsifying agents to properly remove grease, grime and other debris for steel pipe. Volume of cleaner used shall be about 10% of total volume.
   2. System shall be circulated for a minimum of 48 hours with water velocities of a minimum of 5 ft/sec or greater. After completed all strainers shall be removed and cleaned thoroughly. House pumps are acceptable to circulate water.
   3. The system shall be entirely drained and flushed out to remove all of the cleaner from the system as quickly as possible after cleaning to prevent debris from settling. All strainers shall be removed and thoroughly cleaned after no more dirt and cleaner is visible in the flushing water as it leaves the system.

D. Final fill:
   1. All air vents shall be opened to allow air to escape during filling.
   2. Reconnect all flex connections to equipment.
   3. System shall be drained and filled with a local domestic/softened water mixture as required by chemical treatment supplier. System shall be filled with pressure reducing valve at the specified fill pressure.

E. Purging: Purpose is to remove all air from the system:
   1. System shall be circulated for a minimum of one hour with water velocities of a minimum of 5 ft/sec or greater until all visible air is removed.

F. Final chemical addition: Purpose is to install chemicals during inhibitor as required:
   1. After the above final fill and purging has been completed and accepted by the engineer/owner the final chemical addition can be done.
   2. Chemical treatment shall be added to the system after thoroughly mixing water per the manufacturer’s recommendations. Chemical treatment shall include inhibitors. Quantities and concentrations of inhibitor/chemicals should be applied per the manufacturer’s specifications and approval submittals.
   3. System water shall be tested for chemical inhibitor concentrations, reserve alkalinity and PH. Reports shall be submitted to engineer/owner.
   4. All records and documentation shall be kept and given to the owner upon completion.

END OF SECTION
SECTION 23 21 16

UNDERGROUND HYDRONIC PIPING

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
A. Pipe and pipe fittings.
B. Valves.
C. Heating water piping system.
D. Chilled water piping system.

1.03 RELATED SECTIONS
A. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping
B. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
C. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
D. Section 23 05 53 - Identification for HVAC Piping and Equipment
E. Section 23 07 19 - HVAC Piping Insulation
F. Section 23 21 13 - Above Ground Hydronic Piping
G. Section 23 21 19 - Hydronic Specialties

1.04 REFERENCES
A. ASME B31.9 - Building Services Piping.
B. ASME BPVC-IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators - Welding Brazing and Fusing Qualifications.
F. ANSI/ASME B16.3 - Malleable Iron Threaded Fittings Class 150 and 300.

1.05 REGULATORY REQUIREMENTS
A. Conform to ASME B31.9.

1.06 QUALITY ASSURANCE
A. Valves: Manufacturer's name and pressure rating marked on valve body.
B. Welding Materials and Procedures: Conform to ASME BPVC-IX and applicable state labor regulations.
C. Welders Certification: In accordance with ASME BPVC-IX.

1.07 SUBMITTALS
A. Submit product data under provisions of Division One.
B. Include data on pipe materials, pipe fittings, valves, and accessories.
C. Include welder’s certification of compliance with ASME BPVC-IX.
1.08 DELIVERY, STORAGE, AND HANDLING
   A. Deliver products to site under provisions of Division One.
   B. Store and protect products under provisions of Division One.
   C. Deliver and store valves in shipping containers with labeling in place.

PART 2 - PRODUCTS

2.01 PRE-INSULATED PIPE
   A. Pipe shall be the pre-insulated type, as manufactured by Thermacor Process Inc., Perma Pipe, or "approved equal." All sections shall be factory fabricated to job dimensions with all fittings, anchors, and other accessories.
   B. Polyurethane foam insulation shall be injected into the annular space between carrier pipe and jacket with one shot to the thicknesses shown for the specific pipe size. Insulation shall be rigid, 90-95% closed cell polyurethane with a 2.5 to 3.5 pounds per cubic foot density and a coefficient of thermal conductivity (K Factor) of 0.14 at 50 degrees F or 0.17 at 75 degrees F and conform to HH-I-1751/4.
   C. Jackets for pre-insulated piping, including fittings, shall be HDPE in accordance with ASTM D1248, Type 3, Class C. For systems where the entire surface of the factory applied pipe insulation can be visually inspected prior to the application of the jacket, the minimum thickness of the jacket shall be 80 mils for pipe sizes 6” and below, 100 mils for sizes 8”-12”, 102 mils for 14”-20”, and 150 mils 24” and larger. For systems manufactured by injection of urethane foam into the annulus between the carrier pipe and jacket, thereby not allowing visual inspection of the entire insulation surface, jacket thickness shall be 50% greater than the above minimums.

<table>
<thead>
<tr>
<th>MINIMUM INSULATION THICKNESS R - VALUE</th>
<th>Chilled Water</th>
<th>Hot Water</th>
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<tbody>
<tr>
<td>Pipe Size (in.)</td>
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<tr>
<td>=1.5”</td>
<td>3.7</td>
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<tr>
<td>&gt;1.5”-4”</td>
<td>5.6</td>
<td>7.4</td>
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<tr>
<td>&gt;4”</td>
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   D. Carrier pipe shall be standard weight, carbon steel, seamless or ERW, ASTM A106/A106M, ASTM A53/A53M, Grade B. All joints shall be butt-welded for 2-1/2” and greater, and socket or butt-welded for 2” and below. Pipe fittings shall be forged, long radius bends, beveled for butt welding, having a wall thickness equal to the pipe.
   E. Anchors shall be pre-insulated and jacketed at the factory and provided at locations shown on the Contract Drawings. Factory anchors shall be encased in concrete, per the manufacturer’s recommendations, keyed into undisturbed soil. Manufacturer shall provide expansion pillows at expansion bends and include details of thickness, length, and location in data submitted for approval. Expansion pillows and anchors are not required for chilled water systems.
   F. Fittings shall be field insulated with liquid urethane foam insulation, jacketed with a PVC fitting cover and wrapped with polyethylene backed, pressure sensitive butyl rubber tape, or pressure sensitive PVC tape.
   G. Underground systems shall be buried in a trench not less than two (2) feet deeper than the top of the pipe and not less than twelve inches wider than the combined O.D. of all piping systems. All backfill material shall be clean bank sand to a minimum thickness of 24 inches over the top of the jacket to meet H-20 highway loading. All piping will be pressure tested for 150 psi for 48 hours prior to cover-up.
   H. A representative of the manufacturer shall be present during critical periods of installation and testing, to verify that the installation is being made in accordance with the manufacturer's recommendations.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. All pipes shall be installed in accordance with the manufacturer’s recommendations and printed installation instructions.
   B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Contractor's price shall include all items required as per
3.02 PREPARATION
A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt on inside and outside before assembly.
C. Prepare piping connections to equipment with flanges or unions.
D. After completion, fill, clean, and treat systems.
E. Provide access for valves located underground. Coordinate size and location of access doors with Division 8.
F. Install valves with stems upright only, not inverted.

3.03 PIPE FABRICATION
A. All pipes shall be cut accurately to measurements established at the site and shall be worked into place without springing or forcing. Piping layout and installation shall be made in the most advantageous manner possible with respect to valve access and clearance from other work.
B. All changes in directions shall be made with fittings; field bending and mitering of pipe is prohibited.
C. Piping shall be carefully sloped so as to eliminate traps and pockets.
D. Where pipes change size eccentric fittings shall be used to prevent the pocketing of air.
E. Group piping whenever practical at common elevations.

3.04 OFFSETS AND FITTINGS
A. Due to the small scale of the Drawings, it is not possible to indicate all offsets, fittings, etc. which may be required. The Contractor shall carefully investigate the site and conditions affecting the work, and shall take such steps as may be required to meet such conditions.

3.05 PIPE SLEEVES
A. All pipes passing through masonry and concrete construction shall be fitted with sleeves.
B. Each sleeve shall extend through the respective wall and shall project 3 inches on both sides. Sleeves shall be two pipe sizes larger. Sleeves shall be made of galvanized steel pipe.

3.06 ISOLATION VALVES
A. All piping systems shall be provided with line size shut-off valves located at branch connections to mains and at other locations as indicated and required.

3.07 AUTOMATIC VENT VALVES
A. Automatic vent valves shall be installed at high points and at any other air pockets of all closed circulating piping systems.

3.08 TESTING OF PIPING SYSTEMS
A. During the progress of the Work and upon completion, tests shall be made as specified herein and as required by Authorities Having Jurisdiction, including Inspectors, Owner or Architect. The Architect or duly authorized Construction Inspector shall be notified in writing at least 2 working days prior to each test or other Specification requirement which requires action on the part of the Construction Inspector.
B. Tests shall be conducted as part of this Work and shall include all necessary instruments, equipment, apparatus, and service as required to perform the tests with qualified personnel. Submit proposed test procedures, recording forms, and test equipment for approval prior to the execution of testing.
C. Tests shall be performed before piping of various systems have been covered or furred-in. For insulated piping systems, testing shall be accomplished prior to the application of insulation.
D. All piping systems shall be tested and proved absolutely tight for a period of not less than 2 hours at a pressure of 150 psig or 150% of design pressure, whichever is greater. Tests shall be witnessed by the Engineer or an authorized representative and pronounced satisfactory before pressure is removed or any water drawn off.
E. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to a like new condition. Leaking pipe joints, or defective pipe, shall be removed and replaced with acceptable materials. Test shall be repeated after repairs are completed and shall continue until such time as the entire test period expires without the discovery of any leaks, damage, or defects.

3.09 PIPE CLEANING AND STERILIZATION

A. After piping systems have been pressure tested and approved for tightness, they shall be thoroughly cleaned and flushed using an approved pipe cleaning compound.

B. All temporary connections required for cleaning, purging and circulating are included in this Section. Provide suitable pipe bypasses at each coil and heat exchanger during this cleaning operation. All air vents, gauges, strainers, etc., valved connections in piping systems shall be blown clean after cleaning operation is completed.

C. After cleaning, drain the system, fill with fresh water and flush thoroughly until clear water is obtained. Purge all air from the system with the installed manual and automatic air vents.

END OF SECTION
SECTION 23 21 19

HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
   A. Air vents.
   B. Air separators.
   C. Strainers.
   D. Pump suction fittings.
   E. Flow indicators, controls, meters.
   F. Radiator valves.
   G. Relief valves.

1.03 RELATED SECTIONS
   A. Section 23 21 13 - Above Ground Hydronic Piping
   B. Section 23 21 16 - Underground Hydronic Piping
   C. Section 23 21 23 - Hydronic Pumps
   D. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC

1.04 REFERENCES
   A. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels.

1.05 QUALITY ASSURANCE
   A. Manufacturer: For each product specified, provide components by same manufacturer throughout.
   B. Conform to ASME BPVC-VIII-1 for manufacturer of tanks.

1.06 OPERATION AND MAINTENANCE DATA
   A. Submit operation and maintenance data under provisions of Division One.
   B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.07 DELIVERY, STORAGE, AND HANDLING
   A. Deliver products to site under provisions of Division One.
   B. Store and protect products under provisions of Division One.

1.08 OPERATIONS PERSONNEL TRAINING
   A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
      1. Purpose of equipment.
      2. Principle of how the equipment works.
      3. Important parts and assemblies.
      4. How the equipment achieves its purpose and necessary operating conditions.
      5. Most likely failure modes, causes and corrections.
      6. On site demonstration.
PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - EXPANSION TANKS
   A. Bell and Gossett.
   B. TACO.
   C. Wessels Co.
   D. John Wood

2.02 EXPANSION TANKS
   A. Construction: Closed, welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; 125 psi rating; cleaned, prime coated, and supplied with steel support saddles; with tappings for installation of accessories.
   B. Gage Glass Set: Brass compression stops, guard, and 3/4 inch red line glass, maximum 24 inches length, long enough to cover tank for 2 inches above bottom to 2 inches below top.
   C. Quick Connect Air Inlet: Automotive tire valve type, manual air vent, tank drain, and pressure relief valve.
   D. Automatic Cold Water Fill Assembly: Pressure reducing valve, reduced pressure double check backflow preventer, test cocks, strainer, vacuum breaker, and valved by-pass.
   E. Hot Water Heating System: Set expansion tank pressure relief valve at 20 psi maximum and pressure reducing valve at 12 psi.
   F. Chilled Water System: Set expansion tank pressure relief valve at 25 psi maximum and pressure reducing valve at 12 psi.

2.03 ACCEPTABLE MANUFACTURERS - DIAPHRAGM-TYPE COMPRESSION TANKS
   A. Bell and Gossett.
   B. TACO.
   C. Wessels Co.
   D. John Wood

2.04 DIAPHRAGM-TYPE COMPRESSION TANKS
   A. Construction: Welded steel, tested and stamped in accordance with ASME BPVC-VIII-1; supplied with National Board Form U-1, rated for working pressure of 125 psig, with flexible EPDM diaphragm sealed into tank, and steel legs or saddles.
   B. Accessories: Pressure gage and air-charging fitting, tank drain; pre-charge to 12 psig.

2.05 ACCEPTABLE MANUFACTURERS - CHILLED WATER VOLUME TANKS
   A. TACO.
   B. Wessels Co.
   C. John Wood.
   D. Reco.

2.06 ACCEPTABLE MANUFACTURERS - AIR VENTS
   A. Armstrong.
   B. Bell and Gossett/ITT Hoffman.
   C. IMI Flow Design.

2.07 AIR VENTS
   A. Manual Type: Short vertical sections of 2 inch diameter pipe to form air chamber, with 1/8 inch brass needle valve at top of chamber.
   B. Float Type: Brass or semi-steel body, copper float, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
   C. Washer Type: Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut-off, and integral spring loaded ball check valve.

2.08 ACCEPTABLE MANUFACTURERS - AIR SEPARATORS
   A. Bell and Gossett.
B. Thrush.
C. TACO.
D. Spirotherm

2.09 AIR SEPARATORS
A. Dip Tube Fitting: For 125 psig operating pressure; to prevent free air from rising into system.
B. In-line Air Separators: Cast iron for sizes 1-1/2 inch and smaller, or steel for sizes 2 inch and larger; tested and stamped in accordance with ASME BPVC-VIII-1; for 125 psig operating pressure.
C. Air Elimination Valve: Bronze, float operated, for 125 psig operating pressure.
D. Combination Air/Dirt Separators: Steel, tested and stamped in accordance with ASME BPVC-VIII-1, for 150 psig operating pressure, with air elimination valve, internal coalescing medium, tangential inlet and outlet connections, and bottom drain connection with isolation ball valve.

2.10 ACCEPTABLE MANUFACTURERS - STRainers
A. Armstrong.
B. Bell and Gossett.
C. IMI Flow Design.
D. Mueller Steam Specialty.
E. Victaulic (For grooved systems only)

2.11 STRAINERS
A. Size 2 inch and Under: Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32 inch stainless steel perforated screen.
B. Size 2-1/2 inch to 4 inch: Flanged or grooved iron body for 175 psig working pressure, Y pattern with 3/64 inch stainless steel perforated screen.
C. Size 6 inch and Larger: Flanged or grooved iron body for 175 psig working pressure, basket pattern with 1/8 inch stainless steel perforated screen.

2.12 ACCEPTABLE MANUFACTURERS - PUMP SUCTION FITTINGS
A. Bell and Gossett.
B. TACO.
C. Victaulic (For grooved systems only)

2.13 SUCTION FITTINGS
A. Fitting: Angle pattern, cast-iron body, threaded for 2 inch and smaller, flanged or grooved for 2-1/2 inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16 inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.
B. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.14 ACCEPTABLE MANUFACTURERS - FLOW INDICATORS
A. Bell and Gossett.
B. Watson McDaniel.

2.15 FLOW INDICATORS
A. Brass construction, threaded for insertion into piping system, packless, with paddle with removable segments, vapor proof electrical compartment with switches.

2.16 ACCEPTABLE MANUFACTURERS - FLOW CONTROLS
A. Bell and Gossett/ITT Hoffman.
B. IMI Flow Design.
C. TACO.
D. Victaulic/TA
2.17 FLOW CONTROLS
   A. Construction: Brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet, and outlet, blowdown/backflush drain.
   B. Calibration: Control flow within 5 percent of selected rating, over operating pressure range of 10 times minimum pressure required for control.
   C. Control Mechanism: Stainless steel or nickel plated brass piston or regulator cup, operating against stainless steel helical or wave formed spring.
   D. Accessories: In-line strainer on inlet, and ball valve on outlet.

2.18 ACCEPTABLE MANUFACTURERS - FLOW METERS
   A. Bell and Gossett/ITT Hoffman.
   B. IMI Flow Design.
   C. TACO.
   D. Victaulic/TA.

2.19 FLOW METERS
   A. Orifice principle by-pass circuit with direct reading gauge, soldered, or flanged piping connections for 125 psig working pressure, with shut off valves, and drain and vent connections.
   B. Cast iron, wafer type, orifice insert flow meter for 250 psig working pressure, with read-out valves equipped with integral check valves with gasketed caps.
   C. Calibrated, plug type balance valve with precision machined orifice, readout valves equipped with integral check valves and gasketed caps, calibrated nameplate and indicating pointer.
   D. Cast iron or bronze, globe style, balance valve with handwheel with vernier type ring setting and memory stop, drain connection, readout valves equipped with integral check valves and gasketed caps.
   E. Portable meter consisting of case containing two, 3 percent accuracy pressure gauges with 0-135 inches and 0-60 feet pressure ranges for 500 psig maximum working pressure, color coded hoses for low and high pressure connections, and connectors suitable for connection to read-out valves.

2.20 ACCEPTABLE MANUFACTURERS - RELIEF VALVES
   A. Bell and Gossett.
   B. McDonnell-Miller.
   C. TACO.

2.21 RELIEF VALVES
   A. Bronze body, teflon seat, stainless steel stem and springs, automatic, direct pressure actuated, capacities ASME certified and labelled.

PART 3 - EXECUTION

3.01 INSTALLATION AND APPLICATION
   A. Install specialties in accordance with manufacturer’s instructions to permit intended performance.
   B. Support tanks inside building from building structure in accordance with manufacturer’s instructions.
   C. Where large air quantities can accumulate, provide enlarged air collection standpipes.
   D. Provide manual air vents at system high points and as indicated on details and drawings.
   E. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
   F. Provide air separator on suction side of system circulation pump and connect to expansion tank.
   G. Provide valved drain and hose connection on strainer blow down connection.
H. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
I. Support pump fittings with floor mounted pipe and flange supports.
J. Provide relief valves on pressure tanks; and on low pressure side of reducing valves, heat exchangers, and expansion tanks.
K. Select system relief valve capacity so that it is greater than make-up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
L. Pipe relief valve outlet to nearest floor drain.
M. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.

END OF SECTION
SECTION 23 21 23

HYDRONIC PUMPS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED
   A. In-line circulators.
   B. Vertical in-line pumps.
   C. Close coupled pumps.
   D. Base mounted pumps.

1.03 RELATED SECTIONS
   A. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
   B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
   C. Section 23 07 16 - HVAC Equipment Insulation
   D. Section 23 07 19 - HVAC Piping Insulation
   E. Section 23 21 16 - Underground Hydronic Piping

1.04 REFERENCES
   A. NEMA MG 1 - Motors and Generators.
   B. UL 778 - Standard for Motor-Operated Water Pumps.

1.05 QUALITY ASSURANCE
   A. Manufacturer: Company specializing in manufacture, assembly, and field performance of pumps with minimum five years’ experience.
   B. Alignment: Base mounted pumps shall be aligned by qualified millwright and alignment certified.
   C. Impellers: All impellers shall be dynamically balanced.
   D. The Mechanical Contractor shall be responsible for accurately checking all pumping heads, based upon the actual piping and equipment installation. The Contractor shall be responsible for furnishing pumps and motors of proper sizes suitable for the actual installation. Do not provide pumps with capacities less than the amount indicated on the Drawings.

1.06 SUBMITTALS
   A. Submit shop drawings and product data under provisions of Division One.
   B. Submit certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
   C. Submit manufacturer's installation instructions under provisions of Division One.

1.07 OPERATION AND MAINTENANCE DATA
   A. Submit operation and maintenance data under provisions of Division One.
   B. Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.08 DELIVERY, STORAGE, AND HANDLING
   A. Deliver products to site under provisions of Division One.
   B. Store and protect products under provisions of Division One.
1.09 EXTRA PARTS
A. Provide one set of replacement mechanical seals for each size of pump. After the pumps are in operation for ninety days, the Contractor shall check the seals and replace any that are defective. If the replacement seals are not used during the 90-day operational period, they shall be delivered to the Owner.

1.10 OPERATIONS PERSONNEL TRAINING
A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
A. Taco.
B. Aurora.
C. Bell and Gossett.
D. Armstrong
E. Grundfos/Paco.

2.02 GENERAL CONSTRUCTION REQUIREMENTS
A. Balance: Rotating parts, statically and dynamically.
B. Construction: To permit servicing without breaking piping or motor connections.
C. Pump Motors: NEMA MG 1 motors shall operate at 1750 rpm unless specified otherwise. Provide totally enclosed motors when mounted outdoors. Refer to Section 23 05 13.
D. Pump Connections: Flanged, for pipe size two inches and larger. Provide union for pipe sizes less than two inches.
E. Critical speed of each pump shall be at least 115% of the running speed listed in the schedule.
F. Pumps shall meet the minimum quality standards of UL 778.

2.03 IN-LINE CIRCULATORS
A. Type: Horizontal shaft, single stage, direct connected, with resiliently mounted motor for in-line mounting, oil lubricated, for 125 psig maximum working pressure.
B. Casing: Cast iron.
C. Impeller: Brass or bronze, keyed to shaft.
D. Bearings: Two, oil lubricated bronze sleeves.
E. Shaft: Stainless steel with stainless steel sleeve, integral thrust collar.
F. Seal: Carbon rotating against a stationary ceramic seat viton fitted, 275 degrees F maximum continuous operating temperature.
G. Drive: Flexible coupling.

2.04 VERTICAL IN-LINE PUMPS
A. Type: Vertical, single stage, close coupled, radially or horizontally split casing, for in-line mounting, for 175 psig maximum working pressure.
B. Casing: Cast steel, with suction and discharge gauge port, casing wear ring, seal flush connection, drain plug, flanged suction and discharge.
C. Impeller: Bronze, fully enclosed, keyed directly to motor shaft or extension.
D. Shaft: Stainless Steel or Steel with Stainless Steel Sleeve.
E. Seal: Carbon rotating against a stationary ceramic seat viton fitted, 225 degrees F maximum continuous operating temperature.

2.05 CLOSE COUPLED PUMPS
A. Type: Horizontal shaft, single stage, close coupled, radially split casing, for 125 psig maximum working pressure.
B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
C. Impeller: Bronze or Stainless Steel, fully enclosed, keyed to motor shaft extension.
D. Shaft: Stainless steel.
E. Seal: Carbon rotating against a stationary ceramic seat, viton fitted, 225 degrees F maximum continuous operating temperature.

2.06 BASE MOUNTED PUMPS
A. Type: Horizontal shaft, single stage, direct connected, back pull-out, radially or horizontally split casing, for 175 psig maximum working pressure.
B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
C. Impeller: Bronze or Stainless Steel, fully enclosed, keyed to shaft.
D. Bearings: Grease or Permanently lubricated roller or ball bearings, 40,000 hour minimum life.
E. Shaft: Alloy steel with copper, bronze, or stainless steel shaft sleeve.
F. Seal: Carbon rotating against a stationary ceramic seat, viton fitted 225 degrees F maximum continuous operating temperature.
G. Drive: Flexible drop-out coupling with coupling guard.
H. Baseplate: Cast iron or fabricated steel with integral drain rim or pan.
I. For pumps driven by motors 25 horsepower and larger, the steel base shall be fabricated of structural shapes and formed steel sections. The main structural member and formed steel section shall have a depth of at least 1/12 the overall length of the base but not less than 4 inches. The base shall be filled with concrete or grout after installation.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Install pumps in accordance with manufacturer's instructions.
B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
C. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
D. Pumps shall be free of flashing and cavitation at all flow rates from 25% to 125% of design flow under the suction conditions of the pump installation.
E. The impeller selected for compliance with design requirements shall not exceed 95% of cutwater diameter for the selected pump casing size. This shall be clearly certified on the Shop Drawing submittal.
F. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge lines.
G. Provide line sized shut-off valve and strainer on pump suction, and line sized soft seat check valve and shut-off valve on pump discharge.
H. Provide air cock and drain connection on horizontal pump casings.
I. Provide drains for bases and seals, piped to and discharging into floor drains.
J. Lubricate pumps before start-up.
K. Install base mounted pumps on concrete base, with anchor bolts, set and level, and grout in place.

L. Qualified millwright shall check, align, and certify base mounted pumps prior to start-up.

END OF SECTION
SECTION 23 31 13

METAL DUCTWORK

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Low pressure ductwork.
B. Medium and high pressure ductwork.
C. Casings.
D. Kitchen hood ductwork.
E. Duct leakage testing.
F. Duct system protection.
G. Duct system cleaning.

1.02 RELATED SECTIONS

A. Division 9 - Finishes: Weld priming, weather resistant, paint or coating.
B. Section 23 02 00 - Basic Materials and Methods for HVAC
C. Section 23 05 29 - Hangers and Supports for Piping and Equipment - HVAC
D. Section 23 05 93 - Testing, Adjusting, And Balancing
E. Section 23 07 13 - Duct Insulation
F. Section 23 33 00 - Ductwork Accessories
G. Section 23 37 13 - Air Distribution Devices

1.03 REFERENCES

B. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
D. NADCA ACR - Assessment, Cleaning and Restoration of HVAC Systems.
E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
F. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.
G. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.
H. ASHRAE (FUND) ASHRAE Handbook - Fundamentals; Chapter 21 - Duct Design.

1.04 QUALITY ASSURANCE

A. Manufacturer’s Qualifications: Firms regularly engaged in manufacture of metal ductwork products of types, materials and sizes required, whose products have been in satisfactory use in similar service for not less than 5 years.
B. Installer’s Qualifications: Firms with least 3 years of successful installation experience on projects with metal ductwork systems similar to that required for project.
1.05 GENERAL DESCRIPTION
   A. Extent of metal ductwork is indicated on drawings and in schedules, and by requirements of this section.

1.06 SUBMITTALS
   A. Submit shop drawings, duct fabrication standards and product data under provisions of Division One.
   B. Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work.
   C. The contract documents are schematic in nature and are to be used only for design intent. The contractor shall prepare sheet metal shop drawings, fully detailed and drawn to scale, indicating all structural conditions, all plumbing pipe and light fixture coordination, and all offsets and transitions as required to permit the duct to fit in the space allocated and built. All duct revisions required as a result of the contractor not preparing fully detailed shop drawings will be performed at no additional cost.

1.07 DEFINITIONS
   A. Duct Sizes: Inside clear dimensions. For lined ducts, maintain indicated clear size inside lining. Where offsets or transitions are required, the duct shall be the equivalent size based on constant friction rate.
   B. Low Pressure: Low pressure ductwork shall be rated for an operating pressure of 2”. Low pressure ductwork shall be defined as all return, exhaust, and outside air ducts, all supply ductwork associated with constant volume air handling units with a scheduled external static pressure of less than 2”, and all supply ductwork downstream of terminal units in variable volume systems.
   C. Medium Pressure: Medium pressure ductwork shall be rated for an operating pressure of 4”. Medium pressure ductwork shall be defined as all supply ductwork extending from variable volume air handling units to terminal units in variable volume systems with air handling units having a scheduled external static pressure of less than 4”. The supply ductwork of constant volume air handling units having a scheduled external static pressure greater than 2” and less than 4” shall be rated for medium pressure.
   D. High Pressure: High pressure ductwork shall be rated for an operating pressure of 6”, or the scheduled external pressure of the equipment it is connected to, whichever is greater. The supply ductwork of air handling units having a scheduled external static pressure greater than 4” shall be high pressure.

1.08 DELIVERY, STORAGE, AND HANDLING
   A. Protection: Protect shop-fabricated and factory-fabricated ductwork, accessories and purchased products from damage during shipping, storage and handling. Prevent end damage and prevent dirt and moisture from entering ducts and fittings, use sheet metal end caps on any lined duct exposed to the weather.
   B. Storage: Where possible, store ductwork inside and protect from weather. Where necessary to store outside, store above grade and enclose with waterproof wrapping.

PART 2 - PRODUCTS
2.01 DUCTWORK MATERIALS
   A. Exposed Ductwork Materials: Where ductwork is indicated to be exposed to view in occupied spaces, provide materials which are free from visual imperfections including pitting, seam marks, roller marks, stains and discolorations, and other imperfections, including those which would impair painting.
   B. Sheet Metal: Except as otherwise indicated, fabricate ductwork from galvanized sheet steel complying with ASTM A653/A653M.
   C. Stainless Steel Sheet: Where indicated, provide stainless steel complying with ASTM A480/A480M; Type 316; with No. 4 finish where exposed to view in occupied spaces, No. 1 finish elsewhere. Protect finished surfaces with mill-applied adhesive protective paper, maintained through fabrication and installation.
2.02 MISCELLANEOUS DUCTWORK MATERIALS

A. General: Non-combustible and conforming to UL 181, Class 1 air duct materials.

B. Flexible Ducts: Flexmaster U.S.A., Inc. Type 5M, Thermaflex MKE, ATCO #036 or approved equal; corrosive resistant galvanized steel formed and mechanically locked to inner fabric with minimum 1-1/2” thick, R-6 insulation. Flexible duct shall be rated up to at least 10 in.w.g. positive pressure and shall have reinforced metalized outer jacket to comply with UL 181, Class 1 air duct.

C. Sealants: Hard-Cast “iron grip” or approved equal, non-hardening, water resistant, fire resistive and shall not be a solvent curing product. Sealants shall be compatible with mating materials, liquid used alone or with tape or heavy mastic.

D. Ductwork Support Materials: Except as otherwise indicated, provide hot-dipped galvanized steel fasteners, anchors, rods, straps, trim and angles for support of ductwork.
1. For exposed stainless steel ductwork, provide matching stainless steel support materials.
2. For aluminum ductwork, provide aluminum support materials.

2.03 LOW PRESSURE DUCTWORK

A. Fabricate and support in accordance with latest SMACNA (DCS) Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by approved shop drawings. Obtain engineer’s approval prior to using round duct in lieu of rectangular duct.

C. Construct T’s, bends, and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.

D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.

E. Use crimp joints with bead for joining round duct sizes 6 inch smaller with crimp in direction of airflow.

F. Use double nuts and lock washers on threaded rod supports.

2.04 MEDIUM AND HIGH PRESSURE DUCTS

A. Fabricate and support in accordance with SMACNA (DCS) Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.

B. Construct T’s, bends, and elbows with radius of not less than 1½ times width of duct on centerline. Where not possible and where rectangular elbows are used, provide airfoil-turning vanes. Where acoustical lining is required, provide turning vanes of perforated metal with glass fiber insulation. Weld in place.

C. Transform duct sizes gradually, not exceeding 15 degrees divergence and 30 degrees convergence.

D. Fabricate continuously welded medium and high pressure round and oval duct fittings two gauges heavier than duct gauges indicated in SMACNA Standard. Joints shall be minimum 4 inch cemented slip joint, brazed or electric welded. Prime coat welded joints.

E. Provide standard 45 degree lateral wye takeoffs unless otherwise indicated where 90 degree conical tee connections may be used.

2.05 CASINGS

A. Fabricate casings in accordance with SMACNA (DCS) Standards and SMACNA High Pressure Duct Construction Standards and construct for operating pressures indicated.

B. Mount floor mounted casings on 4 inch high concrete curbs. At floor, rivet panels on 8 inch centers to angles. Where floors are acoustically insulated, provide liner of 18 gauge galvanized expanded metal mesh supported at 12 inch centers, turned up 12 inches at
sides with sheet metal shields.

C. Reinforce doorframes with steel angles tied to horizontal and vertical plenum supporting angles. Install hinged access doors where indicated or required for access to equipment for cleaning and inspection. Provide clear wire glass observation ports, minimum 6 X 6 inch size.

D. Fabricate acoustic casings with reinforcing turned inward. Provide 16 gauge back facing and 22 gauge perforated front facing with 3/32 inch diameter holes on 5/32 inch centers. Construct panels 3 inches thick packed with 4.5 lb./cubic foot minimum glass fiber media, on inverted channels of 16 gauge.

PART 3 - EXECUTION

3.01 GENERAL INSTALLATION REQUIREMENTS

A. Obtain manufacturer's inspection and acceptance of fabrication and installation of ductwork at beginning of installation.

B. Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

C. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.

D. Connect terminal units to medium or high pressure ducts with four feet maximum length of flexible duct. Do not use flexible duct to change direction.

E. Connect diffusers or troffer boots to low pressure ducts with 6 feet maximum, 4 feet minimum, length of flexible duct. Hold in place with strap or clamp.

F. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.

G. The interior surface of all ductwork shall be smooth. No sheet metal parts, tabs, angles, or anything else may project into the ducts for any reason, except as specified to be so. All seams and joints shall be external.

H. All ductwork located exposed on roof shall be "crowned" to prevent water from ponding. Ref: Insulation for additional requirements.

I. Where ducts pass through floors, provide structural angles for duct support. Where ducts pass through walls in exposed areas, install suitable sheet metal escutcheons as closer.

J. All angles shall be carried around all four sides of the duct or group of ducts. Angles shall overlap corners and be welded or riveted.

K. All ductwork shall be fabricated in a manner to prevent the seams or joints being cut for the installation of grilles, registers, or ceiling outlets.

L. All duct hangers shall be attached to building structure. Cutting slots in roof or floor decking for hanger straps to be cast in concrete is not acceptable.

3.02 INSTALLATION OF FLEXIBLE DUCTS

A. Maximum Length: For any duct run using flexible ductwork, do not exceed 6'-0" extended length.

B. Installation: Install in accordance with Section III of SMACNA (DCS).

3.03 REQUIREMENTS FOR DUCTS BURIED UNDERGROUND

A. Slope underground ducts to plenums or low pump-out points at 1:500. Provide access doors for inspection.

B. Coat buried, metal ductwork without factory jacket with one coat and seams and joints with additional coat of asphalt base protective coating.

C. Insulate buried supply duct runs over 50 feet long with one inch thick insulation covered with plastic vapor barrier.

D. Encase buried metal ductwork in 3 inch minimum of concrete. Provide adequate tie-down points to prevent ducts from floating during concrete placement. Introduce no heat into ducts for 20 days following placement of concrete.
3.04 REQUIREMENTS FOR UNIT CASINGS
A. Set plenum doors 6 to 12 inches above floor. Arrange door swings so that fan static pressure holds door in closed position.

3.05 REQUIREMENTS FOR KITCHEN HOOD EXHAUST DUCT
A. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for cleanout.
B. Provide access openings in each change in direction, located on sides of duct 1½” minimum from bottom, and fitted with grease-tight covers of same material as duct
C. Use stainless steel for ductwork exposed to view.

3.06 DUCTWORK APPLICATION SCHEDULE
A. Ductwork materials shall be provided to comply with the following:

<table>
<thead>
<tr>
<th>AIR SYSTEM</th>
<th>MATERIAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low Pressure Supply</td>
<td>Galvanized Steel, Aluminum</td>
</tr>
<tr>
<td>Medium and High Pressure Supply</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>Return and Relief</td>
<td>Galvanized Steel, Aluminum</td>
</tr>
<tr>
<td>General Exhaust</td>
<td>Galvanized Steel, Aluminum</td>
</tr>
<tr>
<td>Outside Air Intake</td>
<td>Galvanized Steel</td>
</tr>
<tr>
<td>Emergency Generator Ventilation</td>
<td>Carbon Steel</td>
</tr>
</tbody>
</table>

3.07 DUCTWORK HANGERS AND SUPPORTS
A. All ductwork shall be properly suspended or supported from the building structure. Hangers shall be galvanized steel straps or hot-dipped galvanized rod with threads pointed after installation. Strap hanger shall be attached to the bottom of the ductwork, provide a minimum of two screws one at the bottom and one in the side of each strap on metal ductwork. The spacing, size and installation of hangers shall be in accordance with the recommendations of the latest SMACNA edition.
B. All duct risers shall be supported by angles or channels secured to the sides of the ducts at each floor with sheet metal screws or rivets. The floor supports may also be secured to ducts by rods, angles or flat bar to the duct joint or reinforcing. Structural steel supports for duct risers shall be provided under this Division.

3.08 AIR DUCT LEAKAGE: (FROM SMACNA DUCT STANDARDS LATEST EDITION) TEST ALL DUCTWORK (DESIGNED TO HANDLE OVER 1,000 CFM) AS FOLLOWS:
A. Test apparatus
1. A source of high pressure air-a portable rotary blower or a tank type vacuum cleaner.
2. A flow measuring device consisting of straightening vanes and an orifice plate mounted in a straight tube with properly located pressure taps. Each orifice assembly shall be accurately calibrated with its own calibration curve. Pressure and flow readings shall be taken with U-tube manometers.
B. Test Procedures
1. Test for audible leaks as follows:
2. Close off and seal all openings in the duct section to be tested. Connect the test apparatus to the duct by means of a section of flexible duct.
   a. Start the blower with its control damper closed.
   b. Gradually open the inlet damper until the duct pressure reaches 1.5 times the standard designed duct operating pressure.
   c. Survey all joint for audible leaks. Mark each leak and repair after shutting down blower. Do not apply a retest until sealants have set.
3. After all audible leaks have been sealed, the remaining leakage should be measured with the orifice section of the test apparatus as follows:
   a. Start blower and open damper until pressure in duct reaches 50% in excess of designed duct operating pressure.
   b. Read the pressure differential across the orifice on manometer No. 2. If there is no leakage, the pressure differential will be zero.
   c. Total allowable leakage shall not exceed one (1) percent of the total system design air flow rate. When partial sections of the duct system are tested, the
summation of the leakage for all sections shall not exceed the total allowable leakage.

d. Even though a system may pass the measured leakage test, a concentration of leakage at one point may result in a noisy leak which, must be corrected.

4. Testing Report
a. Contractor shall provide a testing report for each air system to the engineer. The report shall indicate the completion of testing and compliance with testing specification.

b. All duct testing reports shall be included in the final close out documents.

3.09 DUCT SYSTEM PROTECTION

A. Provide temporary closures at the ends of ducts which are not connected to equipment or air distribution devices at time of ductwork installation; provide temporary closure of polyethylene film or other covering which will prevent entrance of dust and debris until time connections are to be completed.

B. Provide temporary construction filters on air handling equipment and/or return air ductwork during construction to protect ductwork and equipment from dust.

C. Any ductwork stored on site with observable dirt or debris inside shall be cleaned by a third party.

D. If the air handling system has been operated without temporary construction filters or if the integrity of the temporary closures has been compromised, the contractor shall have the duct system cleaned per the following section.

3.10 DUCT SYSTEM CLEANING

A. For renovation projects and HVAC retrofit applications wherein existing duct systems are scheduled to be re-used, or where required by the Duct System Protection section above, the contractor shall have the existing duct systems cleaned in accordance with the current published standards of ASHRAE, NADCA ACR and as indicated below.

B. Duct system cleaning method used shall incorporate the use of vacuum collection devices that are operated continuously during cleaning. A vacuum device shall be connected to the downstream end of the section being cleaned through a predetermined opening. The vacuum collection device must be of sufficient power to render all areas being cleaned under negative pressure, such that containment of debris and the protection of the indoor environment is assured.

C. All vacuum devices exhausting air inside the building shall be equipped with HEPA filters (minimum efficiency), including hand-held vacuums and wet-vacuums.

D. All vacuum devices exhausting air outside the facility shall be equipped with Particulate Collection including adequate filtration to contain debris removed from the HVAC system. Such devices shall exhaust in a manner that will not allow contaminants to re-enter the facility. Release of debris outdoors must not violate any outdoor environmental standards, codes or regulations.

E. Fibrous glass thermal or acoustical insulation elements present in any equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment, while the HVAC system is under constant negative pressure, and not permitted to get wet in accordance with applicable NADCA and NAIMA standards and recommendations.

F. Duct cleaning method used shall not damage the integrity of the ductwork, nor damage porous surface materials such as liners inside the ductwork or system components.

G. Replace the fiberglass material if there is any evidence of damage, deterioration, delamination, friable material, mold or fungus growth, or moisture such that fibrous glass materials cannot be restored by cleaning or resurfacing with an acceptable insulation repair coating.

H. Clean external surfaces of foreign substances which might cause corrosive deterioration of metal or, where ductwork is to be painted, might interfere with painting or cause paint deterioration.

I. Strip protective paper from stainless ductwork surfaces, and repair finish wherever it has been damaged.

J. Cleaning Report: Contractor shall provide a report to the Owner indicating the completion of duct cleaning per specification and areas of the duct system found to be damaged.
and/or in need of repair.

3.11 DUCT JOINTS AND SEAMS

A. All ductwork shall be constructed to Seal Class A, as referenced in SMACNA (DCS).

B. All non-welded joints and seams shall be sealed. This includes but is not limited to:
   1. Transverse joints.
   2. Longitudinal seams.
   3. Duct wall penetrations.
   4. Spin-ins, taps, and other branch connections.
   5. Access doors, access panels, and duct connections to equipment.

C. Openings for rotating shafts shall be sealed with bushings.

END OF SECTION
SECTION 23 33 00
DUCTWORK ACCESSORIES

PART 1 - GENERAL
1.01 WORK INCLUDED
   A. Volume control dampers.
   B. Shutoff Dampers.
   C. Round Duct Taps.
   D. Conical Duct Taps.
   E. Fire dampers.
   F. Combination fire and smoke dampers.
   G. Back draft dampers.
   H. Air turning devices.
   I. Flexible duct connections.
   J. Duct access doors.
   K. Duct test holes.

1.02 RELATED WORK
   A. Section 23 02 00 - Basic Materials and Methods for HVAC
   B. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
   C. Section 23 31 13 - Metal Ductwork

1.03 REFERENCES
   A. AMCA 500-D - Laboratory Methods of Testing Dampers for Rating.
   E. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
   F. UL 33 - Safety Heat Responsive Links for Fire-Protection Service.
   G. UL 555 - Standard for Fire Dampers.
   H. UL 555S - Standard for Smoke Dampers.

1.04 SUBMITTALS
   A. Submit shop drawings and product data under provisions of Division One.
   B. Provide shop drawings for shop fabricated assemblies indicated, including volume control dampers duct access doors duct test holes. Provide product data for hardware used.
   C. Submit manufacturer's installation instructions under provisions of Division 1, for fire dampers and combination fire and smoke dampers.

PART 2 - PRODUCTS
2.01 VOLUME CONTROL DAMPERS
   A. Fabricate in accordance with SMACNA (DCS), and as indicated.
   B. Fabricate splitter dampers of material same gauge as duct to 24 inches size in either direction, and two gauges heavier for sizes over 24 inches.
   C. Fabricate splitter dampers of double thickness sheet metal to streamline shape. Secure blade with continuous hinge or rod. Operate with minimum 1/2 inch diameter rod in self aligning, universal joint, action flanged bushing, with set screw.
   D. Fabricate single blade dampers for duct sizes to 9-1/2 x 24 inch.
   E. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12 x 72 inch.
1. Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

2. On outside air, return air, and all other dampers required to be low leakage type, provide galvanized blades and frames, seven inches wide maximum, with replaceable vinyl, EPDM, silicone rubber seals on blade edges and stainless steel side seals. Provide blades in a double sheet corrugated type construction for extra strength. Provide hat channel shape frames for strength and blade linkage enclosure to keep linkage out of the air stream. Construction leakage not to exceed 1/2%, based on 2,000 fpm and 4 inch static pressure.

F. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide oil-impregnated nylon or sintered bronze bearings.

G. Provide locking, indicating quadrant regulators on single and multi-blade dampers. Where rod lengths exceed 30 inches provide regulator at both ends.

H. On insulated ducts mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

2.02 SHUTOFF DAMPERS
A. Fabricate in accordance with SMACNA (DCS), and as indicated.
B. Provide Class I multi-blade damper of parallel blade pattern for all ductwork systems which penetrate the building thermal envelope in accordance with ICC (IECC) and ASHRAE Std 90.1 I-P.
1. Damper shall be constructed of one-piece 16 ga. roll-formed galvanized steel hat-shaped channel frame. Blades shall be 14 ga. roll-formed galvanized steel, airfoil type. Blade edge seals shall be neoprene gaskets mechanically locked to blade edge. Bearings shall be 304 stainless steel, oil-impregnated and self-lubricating sleeve type, turning in extruded holes in damper frame.
C. Shutoff dampers shall have an air leakage rate not greater than 4 cfm/ft² of damper surface area at 1.0 in.w.g. and shall be labeled by an approved agency when tested in accordance with AMCA 500-D for such purpose.

2.03 ROUND DUCT TAPS
A. Taps to trunk duct for round flexible duct shall be spin-in fitting with locking quadrant butterfly damper, model no. FLD-B03 by Flexmaster or approved equal.

2.04 CONICAL DUCT TAPS
A. Taps to trunk duct for primary air inlet to all VAV terminal units shall be conical fitting, model no. CB by Flexmaster or approved equal.

2.05 ACCEPTABLE MANUFACTURERS - FIRE DAMPERS AND COMBINATION FIRE AND SMOKE DAMPERS
A. Greenheck.
B. Louvers and Dampers Inc.
C. Ruskin.
D. Nailor Industries.
E. Pottorff

2.06 FIRE DAMPERS
A. Fabricate in accordance with NFPA 90A and UL 555, and as indicated.
B. Provide curtain type dampers of galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations. Configure with blades out of air stream.
C. Fabricate multiple blade fire dampers per UL with 16 gauge minimum galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock.
D. Fusible links, UL 33, shall separate at 165 degrees F. Provide adjustable link straps for combination fire/balancing dampers.
2.07 COMBINATION FIRE AND SMOKE DAMPERS
A. Fabricate in accordance with NFPA 90A, UL 555, UL 555S and as indicated.
B. Provide factory sleeve for each damper. Install damper operator on exterior of sleeve and link to damper operating shaft.
C. Fabricate with multiple blades with 16 gauge galvanized steel frame and blades, oil-impregnated bronze or stainless steel sleeve bearings and plated steel axles, stainless steel jamb seals, 1/8 x 1/2 inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock, and 1/2 inch actuator shaft.
   1. Operators shall be spring return electric type suitable to operate on 120 VAC, 60 cycle.
   2. Operators shall be UL listed and labeled.

2.08 SMOKE DAMPERS
A. Fabricate in accordance with NFPA 90A and UL 555, UL 555S and as indicated.
B. Motorized Smoke Dampers: multi-blade type, normally open with power on, close automatically when power is interrupted, UL-listed and labeled damper and damper operator.

2.09 ACCEPTABLE MANUFACTURERS - BACKDRAFT DAMPERS
A. Greenheck
B. American Warming and Vent.
C. Louvers and Dampers Inc.
D. Ruskin.
E. Pottorff
F. Substitutions: Under provisions of Division One.

2.10 BACKDRAFT DAMPERS
A. Gravity back draft dampers, size 18 x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturers standard construction.
B. Fabricate multi-blade, parallel action gravity balanced back draft dampers of 16 gauge galvanized steel, or extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90 degree stop, steel ball bearings, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.
C. Gravity backdraft dampers shall have an air leakage not greater than 20 cfm/ft² where not less than 24 inches in either dimension and 40 cfm/ft² where less than 24 inches in either dimension. The rate of air leakage shall be determined at 1.0 in.w.g. when tested in accordance with AMCA 500-D for such purpose.

2.11 ACCEPTABLE MANUFACTURERS - AIR TURNING DEVICES
A. Young Regulator.
B. Titus.
C. Tuttle and Bailey.
D. Substitutions: Under provisions of Division One.

2.12 AIR TURNING DEVICES
A. On duct sizes less than 12 x 12, multi-blade device with blades aligned in short dimension; steel or aluminum construction; with individually adjustable blades, mounting straps.
B. Multi-blade device with radius blades attached to pivoting frame and bracket, steel or aluminum construction, with worm drive mechanism with 18 inch long removable key operator.

2.13 ACCEPTABLE MANUFACTURERS - FLEXIBLE DUCT CONNECTIONS
A. Metaledge.
B. Ventglass.
C. Substitutions: Under provisions of Division One.
2.14 FLEXIBLE DUCT CONNECTIONS TO AIR MOVING EQUIPMENT
   A. Fabricate in accordance with SMACNA (DCS) and as indicated.
   B. UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 20 oz. per sq. yd., approximately 6 inches wide, crimped into metal edging strip.

2.15 ACCEPTABLE MANUFACTURERS - DUCT ACCESS DOORS
   A. Greenheck.
   B. American Warming and Vent.
   C. Ruskin.
   D. Titus.
   E. Substitutions: Under provisions of Division One.

2.16 DUCT ACCESS DOORS
   A. Fabricate in accordance with SMACNA (DCS) and as indicated.
   B. Review locations prior to fabrication.
   C. Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover. Insulation shall be replaceable without field cutting or patching.
   D. Access doors smaller than 12 inches square may be secured with sash locks.
   E. Provide two hinges and two sash locks for sizes up to 18 inches square, three hinges and two compression latches with outside and inside handles for sizes up to 24 x 48 inches. Provide an additional hinge for larger sizes.
   F. Access doors with sheet metal screw fasteners are not acceptable.

2.17 DUCT TEST HOLES
   A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.
   B. Permanent test holes shall be factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. Install accessories in accordance with manufacturer's instructions.
   B. Balancing Dampers
      1. Provide at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts and as required for air balancing. Use splitter dampers only where indicated.
      2. All regulators mounted on externally insulated ductwork shall have 16 gauge elevated platforms at least 1/8 inch higher than the thickness of the insulation. Damper shaft shall have Ventlock No. 607 bearing mounted on ductwork within elevated platform. If duct is inaccessible the operating handle shall be extended and the regulator installed on the face of the wall or ceiling. Where regulators are exposed in finished parts of the building, they shall be flush type, Ventlock No. 666. All regulators shall be manufactured by Ventlock, or approved equal.
      3. All dampers in lined ductwork shall have bushing to prevent damper damage to liner.
   C. Provide fire dampers at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
   D. Demonstrate re-setting of fire dampers to authorities having jurisdiction and Owner's representative.
   E. Provide gravity backdraft dampers or motorized shutoff dampers in accessible location nearest to exterior wall/roof penetrations and where indicated for all outdoor air intake and exhaust systems to automatically shut when the associated systems or spaces served are not in use.

Ductwork Accessories

23 33 00 - 4
F. Provide flexible duct connections immediately adjacent to equipment in ducts associated with fans and motorized equipment. Provide at least one inch slack at all flexible duct connections.

G. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8 inch size for hand access, 18 x 18 inch size for shoulder access, and as indicated.

H. Provide duct test holes where indicated and required for testing and balancing purposes.

END OF SECTION
SECTION 23 34 00

HVAC FANS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 WORK INCLUDED

A. Centrifugal roof ventilators
B. Ceiling and inline ventilators
C. Roof supply fans.
D. Utility fans

1.03 RELATED SECTIONS

A. Section 23 02 00 - Basic Materials and Methods for HVAC
B. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
C. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
D. Section 23 05 93 - Testing, Adjusting, And Balancing
E. Section 23 09 63 - Energy Management and Control System (EMCS)
F. Section 23 33 00 - Ductwork Accessories

1.04 REFERENCES

D. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
E. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
G. NFPA 70 - National Electrical Code.
I. UL 705 - Power Ventilators.

1.05 QUALITY ASSURANCE

A. UL Compliance: Fans shall be designed, manufactured, and tested in accordance with UL 705.
B. UL Compliance: Fans and components shall be UL listed and labeled.
C. Nationally Recognized Testing Laboratory Compliance (NRTL): Fans and components shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.
D. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
E. Electrical Component Standard: Components and installation shall comply with NFPA 70.
F. Sound Power Level Ratings: Comply with AMCA 301. Test fans in accordance with AMCA 300. Fans shall be licensed to bear the AMCA 300 Seal.
G. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings in accordance with AMCA 210.
1.06 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:

B. Product data for selected models, including specialties, accessories, and the following:
   1. Certified fan performance curves with system operating conditions indicated.
   2. Certified fan sound power ratings.
   3. Motor ratings and electrical characteristics plus motor and fan accessories.
   4. Materials, gages and finishes, include color charts.
   5. Dampers, including housings, linkages, and operators.
   6. Full color paint samples.

C. Shop drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, required clearances, components, and location and size of field connections.

D. Coordination drawings, in accordance with Division 23, Section "Basic Materials and Methods", for roof penetration requirements and for reflected ceiling plans drawn accurately to scale and coordinating penetrations and units mounted above ceiling. Show the following:
   1. Roof framing and support members relative to duct penetrations.
   2. Ceiling suspension members.
   3. Method of attaching hangers to building structure.
   4. Size and location of initial access modules for acoustical tile.
   5. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinkler heads, access panels, and special moldings.

E. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer installed wiring and field installed wiring.

F. Product certificates, signed by manufacturer, certifying that their products comply with specified requirements.

G. Maintenance data for inclusion in Operating and Maintenance Manual specified in Division 1 and Division 23, Section "Basic Materials and Methods".

1.07 DELIVERY, STORAGE, AND HANDLING

A. Fans shall be stored and handled in accordance with the unit manufacturer’s instructions.

B. Lift and support units with the manufacturer’s designated lifting or supporting points.

C. Disassemble and reassemble units as required for movement into the final location following manufacturer’s written instructions.

D. Deliver fan units as a factory-assembled unit to the extent allowable by shipping limitations, with protective crating and covering.

1.08 ENVIRONMENTAL REQUIREMENTS

A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

1.09 OPERATIONS PERSONNEL TRAINING

A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. Greenheck Fan Corporation
B. Loren Cook Company  
C. Pennbarry  
D. ACME  
E. Twin City Fan and Blower  

2.02 GENERAL DESCRIPTION  
A. Provide fans that are factory fabricated and assembled, factory tested, and factory finished with indicated capacities and characteristics.  
B. Fans and Shafts shall be statically and dynamically balanced and designed for continuous operation at the maximum rated fan speed and motor horsepower.  
C. Provide factory baked-enamel finish coat after assembly. Color for roof mounted fans shall be chosen by Architect during the submittal process.  

2.03 CEILING AND INLINE VENTILATORS  
A. Ceiling and inline ventilators shall be direct drive or belt drive as indicated, centrifugal blower type. Fan wheel shall be constructed of galvanized steel and shall be dynamically balanced. The housing shall be constructed of minimum 20 gauge corrosion resistant galvanized steel and acoustically insulated for quiet operation. Blower and motor assembly shall be easily removable from the housing without disturbing the ductwork. The motor shall be permanently lubricated with built-in thermal overload protection and shall be factory tested prior to shipment. The ceiling ventilators shall be furnished standard with a powder-painted white steel grille.  
B. Ventilators shall be certified and licensed to bear the AMCA Seal for Air and Sound Performance. Ventilator performance shall be based on tests and procedures performed in accordance with AMCA 211 and comply with the requirements of the AMCA Certified Ratings Program. Fan sound power level ratings shall be based on tests and procedures performed in accordance with AMCA 311 and comply with the requirements of the AMCA Certified Ratings Program. Ventilators shall be UL listed and CSA certified.  
C. Accessories: The following accessories are required.  
   1. Dampers:  
      a. Aluminum backdraft damper.  
      b. Motor-operated volume control damper.  
      c. L listed ceiling radiation damper for ceiling fans comply with NFPA 90A rated for 3 hours  
   2. Disconnect Switch: Nonfusible type with thermal overload protection.  
   3. Speed Controls: Fan mounted, solid state speed controller.  

2.04 UTILITY FANS  
A. Fans shall be of the direct driven or belt driven utility fan type as indicated with a single width, single inlet housing in AMCA arrangement 10.  
B. The housing shall be constructed of minimum 14 gauge steel with continuously welded or lock formed seams permitting no air leakage. The housing shall be field rotatable to any of the eight standard discharge positions. Housing and bearing supports shall be constructed of minimum 10 gauge welded steel members to prevent vibration and rigidly support the shaft and bearings. Side access inspection port shall be provided for access to the motor compartments.  
C. The fan wheel shall be of the forward curved type C, non-overloading backward inclined, centrifugal fan type and constructed of heavy gauge steel.  
D. Wheels shall be statically and dynamically balanced. The wheel cone and fan inlet cone shall be carefully matched for maximum performance and operating efficiency.  
E. Motors shall be permanently lubricated, heavy duty, ball bearing type carefully matched to the fan load and furnished at the specified voltage, phase and enclosure. The fan shaft shall be ground and polished solid steel mounted in heavy duty, permanently sealed, pillow block ball bearings. Bearings shall be selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast iron type, keyed and securely attached to the wheel and motor shafts. The motor pulley shall be adjustable for final system balancing.
F. Fan performance shall be based on tests conducted in accordance with AMCA 210. Fans shall be licensed to bear the AMCA Certified Ratings Seal for air performance.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install in accordance with manufacturer’s instructions.

B. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.

END OF SECTION
SECTION 23 37 13

AIR DISTRIBUTION DEVICES

PART 1 - GENERAL

1.01 WORK INCLUDED

A. Ceiling air diffusers.
B. Wall registers and grilles.
C. Louvers.
D. Other air devices indicated on drawings and schedules.

1.02 RELATED SECTIONS

A. Section 08 91 00 - Louvers
B. Section 23 02 00 - Basic Materials and Methods for HVAC
C. Section 23 05 93 - Testing, Adjusting, And Balancing
D. Section 23 07 13 - Duct Insulation
E. Section 23 31 13 - Metal Ductwork
F. Section 23 33 00 - Ductwork Accessories

1.03 REFERENCES

A. AHRI 880 (I-P) - Performance Rating of Air Terminals.
B. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
C. AMCA 540 - Test Method for Louvers Impacted by Wind Borne Debris.
D. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.
E. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets.

1.04 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of air distribution devices of types and capacities required, whose products have been in satisfactory use in similar service for not less than 5 years.

B. Codes and Standards:
   1. AHRI Compliance: Test and rate air distribution devices in accordance with AHRI 880 (I-P).
   2. ASHRAE Compliance: Test and rate air distribution devices in accordance with ASHRAE Std 70.
   3. AMCA Compliance: Test and rate louvers in accordance with AMCA 500-L.
   4. AMCA 540 - Test Methods for Louvers Impacted by Wind Borne Debris with Enhanced Protection Approval.
   5. AMCA 550 - Test Method for High Velocity Wind Driven Rain Resistant Louvers.
   6. AMCA Seal: Provide louvers bearing AMCA Certified Rating Seal.
11. IMC - International Mechanical Code.
12. UMC - Uniform Mechanical Code.

1.05 DEFINITIONS
A. Hurricane-prone regions:
   1. The U.S. Atlantic Ocean and Gulf of Mexico coasts where the ultimate design wind speed for Risk Category II Buildings is greater than 115 mph;
   2. Hawaii, Puerto Rico, Guam, Virgin Islands and American Samoa.
B. Wind-borne debris region: Areas within hurricane-prone regions located:
   1. Within 1 mile of the coastal mean high water line where the ultimate design wind speed is 130 mph or greater; or
   2. In areas where the ultimate design wind speed is 140 mph or greater. For Risk Category II buildings and structures and Risk Category III building and structures, except health care facilities, the wind-borne debris region shall be based on Figure 1609.3(1). For Risk Category IV buildings and structures and Risk Category III health care facilities, the wind-borne debris region shall be based on Figure 1609.3(2).
C. Ultimate design wind speed - The ultimate design wind speed for the determination of the wind loads shall be determined by Figures 1609.3(1), 1609.3(2) and 1609.3(3) of ICC (IBC).

1.06 SUBMITTALS
A. Product Data: Submit manufacturer's technical product data for the following:
   1. Air Distribution Devices
      a. Schedule of air distribution devices indicating drawing designation, room location, number furnished, model number, size, and accessories furnished.
      b. Data sheet for each type of air distribution devices, and accessory furnished; indicating construction, finish, and mounting details.
      c. Performance data for each type of air distribution devices furnished, including aspiration ability, temperature and velocity traverses; throw and drop; and noise criteria ratings. Indicate selections on data.
   2. Louvers
      a. Manufacturer's product data including performance data.
      b. Preparation instructions and recommendations.
      c. Storage and handling requirements and recommendations.
      d. Installation methods.
B. Shop Drawings: Submit manufacturer's assembly-type shop drawing for each type of air distribution device and louver, indicating materials, construction, dimensions, accessories, and installation details.
C. Maintenance Data: Submit maintenance data, including cleaning instructions for finishes, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals; in accordance with requirements of Division 1.

1.07 PRODUCT DELIVERY, STORAGE AND HANDLING
A. Deliver air distribution devices wrapped in factory-fabricated fiber-board type containers. Identify on outside of container type of outlet or inlet and location to be installed. Avoid crushing or bending and prevent dirt and debris from entering and settling in devices.
B. Store air distribution devices and louvers in original cartons and protect from weather and construction work traffic in accordance with manufacturer's instructions. Where possible, store indoors; when necessary to store outdoors, store above grade and enclose with waterproof wrapping.
C. Store and dispose of solvent-based materials, and materials used with solvent-based materials, in accordance with requirements of local authorities having jurisdiction.
1.08 WARRANTY
   A. Warrant the installation of the work specified herein for one year against becoming unserviceable or causing an objectionable appearance resulting from defective or nonconforming workmanship.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS - AIR DEVICES
   A. Titus Company
   B. Metalaire Industries, Inc.
   C. Nailor Industries
   D. Krueger
   E. Price

2.02 AIR DEVICES
   A. Unless otherwise indicated, provide manufacturer’s standard air devices when shown of size, shape, capacity, type and accessories indicated on drawings and schedules, constructed of materials and components as indicated and as required for complete installation and proper air distribution.
   B. Provide air devices that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device and listed in manufacturer’s current data.
   C. Unless noted otherwise on drawings, the finish shall be #26 white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering, or deterioration of film. The paint must pass a 250-hour ASTM D870 Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50 inch-pound force applied.
   D. Provide air device with border styles that are compatible with adjacent ceiling or wall system, and that are specially manufactured to fit into the wall construction or ceiling module with accurate fit and adequate support. Refer to architectural construction drawings and specifications for types of wall construction and ceiling systems.
   E. Provide integral volume damper with roll formed steel blades where indicated on drawings or schedules. Dampers shall be opposed blade design with a screwdriver slot or a concealed lever operator for adjustment through the face of the air device.
   F. Air devices designated for fire rated systems shall be pre-assembled with UL classified radiation damper and thermal blanket. Fire rated air devices shall be shipped completely assembled, one assembly per carton; each assembly shall be enclosed in plastic shrink wrap with installation instructions.

2.03 ACCEPTABLE MANUFACTURERS - LOUVERS
   A. Ruskin Manufacturing Company
   B. Greenheck Company
   C. Louvers and Dampers, Inc.
   D. Pottorff
   E. Arrow

2.04 LOUVERS
   A. Louvers not located in hurricane-prone regions or wind-borne debris regions shall meet the requirements of AMCA 500-L for Laboratory Methods of Testing Louvers for Rating and be drainable stationary type louvers.
   B. Louvers located in hurricane-prone regions shall meet the requirements of AMCA 550 for High Velocity Wind Driven Rain without the use of a control damper.
   C. Louvers located in wind-borne debris regions within 30 feet of grade shall meet the requirements of AMCA 540 for Large Missile Impact.
   D. Provide louvers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
E. Provide louvers that have minimum free area and maximum pressure drop as indicated on drawings.

F. Provide louvers with frame and sill styles that are compatible with adjacent substrate, and that are specifically manufactured to fit into construction openings with accurate fit and adequate support, for weatherproof installation. Refer to architectural construction drawings and specifications for types of substrate.

G. Coordinate with Architect for finish and color.

H. Louver Screens: On inside face of exterior louvers, provide 1/2" square mesh anodized aluminum wire bird screens mounted in removable extruded aluminum frames.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All interior surfaces of all air devices shall be painted flat black.

B. See floor plans for type, neck size and CFM of air for all air distribution devices.

C. Install all air distribution devices as detailed on plans and in accordance with manufacturer’s recommendations.

D. The backside of all supply air devices shall be insulated with taped and sealed 1½ inch thick external duct wrap. Refer to 23 07 13 - Duct Insulation.

E. Inspect areas to receive louvers. Notify the Architect of conditions that would adversely affect the installation or subsequent utilization of the louvers. Do not proceed with installation until unsatisfactory conditions are corrected.

F. If opening preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

G. Install louvers at locations indicated on the drawings and in accordance with manufacturer’s instructions.

H. Install louvers plumb, level, in plane of wall, and in alignment with adjacent work.

I. Touch-up, repair or replace any damaged products prior to substantial completion.

END OF SECTION
SECTION 23 41 00

AIR FILTERS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
B. Section 23 02 00 - Basic Materials and Methods for HVAC are included as a part of this Section as though written in full in this document.

1.02 SCOPE
A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.03 REFERENCES
A. ASHRAE Std 52.2 - Method of Testing General Ventilation Air-Cleaning Devices for Removal Efficiency by Particle Size.
B. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.

PART 2 - PRODUCTS

2.01 FILTERS
A. Air filters shall be medium efficiency ASHRAE pleated panels consisting of synthetic media, welded wire media support grid, and beverage board enclosing frame, AAF PREpleat M11-HC, 2-inch thick or approved equal.
B. APPROVED MANUFACTURERS
   1. American Air Filter.
   2. Camfil.
   3. Airguard Industries, Inc.
   5. Filtration Group

2.02 LOW VELOCITY FILTER SECTION
A. Filters shall be of the throwaway cartridge type in 2-inch frames. When installing multiple filters into slide-in frames tape adjacent filters together with duct tape to prevent bypassing of air around the filter. Media shall be rated at 500 feet per minute.
B. Filtering media shall be formed of non-woven reinforced synthetic type filtering media bonded to 96% open area media support grid folded into a non-creased radial pleat design. The filter pack shall be bonded to the enclosing frame to prevent air bypass. Minimum Efficiency Reporting Value of MERV 11 when evaluated under the guidelines of ASHRAE Std 52.2. Initial resistance shall not exceed 0.30 inches water gauge at 500 fpm face velocity.

PART 3 - EXECUTION

3.01 INSTALLATION
A. Filters shall be provided upstream of all cooling coils or other devices with wetted surfaces through which air is supplied to occupiable spaces per ASHRAE Std 62.1.
B. Install differential pressure switch to activate "Filter Dirty" light when pressure difference across filters reaches 0.5 inches w.g. (adjustable). Locate "filter dirty" lights in mechanical rooms with identifying label.
C. Refer to Section 23 02 00 for additional filter information.

END OF SECTION
SECTION 23 41 01

AIR PURIFICATION SYSTEM

PART 1 - GENERAL

1.01 WORK INCLUDED
A. Electronic Ionization Air Purification System

1.02 RELATED SECTIONS
A. Section 23 02 00 - Basic Materials and Methods for HVAC
B. Section 23 41 00 - Air Filters
C. Section 23 73 13 - Modular Indoor Central Station Air Handling Units
D. Section 23 73 26 - Modular Outdoor Central Station Air Handling Units
E. Section 23 74 16 - Rooftop Heating and Cooling Units (Electric Cooling - Gas Heating)
F. Section 23 74 19 - Rooftop Heating and Cooling Units (Electric Cooling - Electric Heat)
G. Section 23 74 21 - Variable Air Volume Rooftop Units
H. Section 23 82 19 - Fan Coil Unit

1.03 REFERENCES
A. ASHRAE Std 62.1 - Ventilation for Acceptable Indoor Air Quality.
B. NFPA 70 - National Electrical Code.
D. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances.
E. UL 746C - Polymeric Materials – Use in Electrical Equipment Evaluations.
F. UL 867 - Electrostatic Air Cleaners.
G. UL 2998 - Environmental Claim Validation Procedure (ECVP) for Zero Ozone Emissions from Air Cleaners.

1.04 QUALITY ASSURANCE
A. The plans and specifications for the air purification system, and the sizing of the systems, have been based on an ionization air purification system as indicated on the drawings and equipment schedules. Alternate systems or manufacturers shall only be considered for acceptance provided that the substituted equipment is equal to the operational characteristics, capacities, and intent of descriptions specified herein. Bidders shall not substitute any equipment covered under this section without written permission from the Engineer and Owner three weeks prior to bid date.
B. Air purifier shall be fabricated by companies whose primary business expertise is the manufacture of commercial and industrial-quality bipolar ionization air purifiers. The manufacturer shall have been in continuous operation for a minimum of ten (10) years. All products shall be manufactured in the USA and a certificate of origin be provided if requested.
C. 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.
D. Projects designed using ASHRAE Std 62.1 IAQ Procedure shall require the manufacturer to provide Indoor Air Quality calculations using the formulas within ASHRAE Std 62.1 to validate acceptable indoor air quality at the quantity of outside air scheduled with the technology submitted. For projects utilizing the ASHRAE Std 62.1 IAQ Procedure the Contractor shall provide a third party IAQ test for the building. Test results must be stamped by a licensed professional engineer prior to submission. Results must be submitted to engineer validating performance reductions versus contaminants of concern.
E. The Air Purification Technology shall have been tested to prove conformance to UL 867 and UL 2998 including the ozone chamber test and peak ozone test for all electronic air cleaning devices.
F. System commissioning shall include ion level measurements to ensure that these design increase levels have been achieved.

1.05 GENERAL DESCRIPTION
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.

1.06 SUBMITTALS
A. Submit manufacturer's documentation in accordance with specification requirements.
B. Submit the following information:
   1. Manufacturer's installation instructions.
   5. Electrical interlocks.
C. Submit recommended clearance dimensions for air flow and service.
D. Submit coordination drawings as specified.
   1. Give consideration to adjacent structures as they affect air flow patterns.
E. Wiring diagrams that detail power, signal, and control wiring. Differentiate between manufacturer installed wiring and field installed wiring.
F. Submit operation and maintenance data under provision of Section 23 02 00.
G. Mark-up a copy of the specifications, indicating in the margin of each paragraph, the following: COMPLY, DO NOT COMPLY, NOT APPLICABLE.

1.07 WARRANTY
A. Provide a parts and labor warranty by the equipment manufacturer for a period of two (2) years from shipment.

1.08 DELIVERY, 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.

1.09 OPERATIONS PERSONNEL TRAINING
A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
A. Global Plasma Solutions
B. Plasma Air
C. AtmosAir Solutions

2.02 DESIGN AND PERFORMANCE CRITERIA
A. Each piece of air handling equipment, so 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 a qualified zero ozone emission product, with less than 0.005 ppm of ozone generation as certified by UL 867 and UL 2998. Manufacturer shall produce documentation of UL 867 and UL 2998 certification prior to the bid and/or during the submittal process.

C. 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. All manufacturers shall provide documentation by an independent NELEC accredited laboratory that proves the product has minimum deactivation 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
   6. Capable of modular field assembly within the air handling equipment.

D. The bi-polar ionization system shall operate in a manner such that equal amounts of positive and negative ions are produced. Uni-polar ion devices shall not be acceptable. Ionizers provided shall be AC type ionizers with each electrode pulsing between positive and negative.
   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.

E. 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.

F. Equipment Requirements for AHUs and RTUs
   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. 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 200 million ions/cc per inch of cooling coil width as measured 1 inch from the cold plasma needles.
      e. Ionization bars shall be provided with magnet mounting kits to prevent penetration into cooling coils.
      f. Ionization bars shall be constructed of UL 94 V-0 and UL 746C composite material.
      g. Device shall be OSPD certified.
      h. Where noted on the Drawings, Ionization systems shall be self-cleaning.
G. Electrical Requirements:
   1. Wiring, conduit and junction boxes shall be installed within housing plenums in accordance with 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 EMCS as well as a local “Plasma On” indication light. Plasma Generators without internal circuitry to sense ionization output shall be provided with separate ion level measurement devices capable of sensing the expected ion levels of the associated equipment.
   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

3.01 GENERAL
   A. The Contractor shall be responsible for maintaining all air systems until one year after substantial completion.

3.02 ASSEMBLY & ERECTION: PLASMA GENERATOR
   A. Install per manufacturer’s installation instructions.
   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.

3.03 TESTING
   A. Provide the manufacturer's recommended electrical tests.
   B. System shall be tested to ensure that the design increase in ion levels have been achieved.

3.04 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
SECTION 23 73 13

MODULAR INDOOR CENTRAL STATION AIR HANDLING UNITS

PART 1 - GENERAL

1.01 WORK INCLUDED
A. Central station air handling unit.

1.02 RELATED SECTIONS
A. Section 23 02 00 - Basic Materials and Methods for HVAC
B. Section 23 05 16 - Expansion Fittings and Loops for HVAC Piping
C. Section 23 05 13 - Common Motor Requirements for HVAC Equipment
D. Section 23 05 26 - Variable Frequency Motor Speed Control for HVAC Equipment
E. Section 23 05 48 - Vibration and Seismic Controls for HVAC Piping and Equipment
F. Section 23 07 13 - Duct Insulation
G. Section 23 31 13 - Metal Ductwork
H. Section 23 33 00 - Ductwork Accessories
I. Section 23 34 00 - HVAC Fans
J. Section 23 41 00 - Air Filters

1.03 REFERENCES
A. AHRI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment.
C. AHRI 430 (I-P) - Performance Rating of Central Station Air-Handling Units.
E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
K. NEMA MG 1 - Motors and Generators.

1.04 QUALITY ASSURANCE
A. Unit performance shall be certified in accordance with AHRI 430 (I-P) for central station air handling units.
B. Coil performance shall be certified in accordance with AHRI 410.
C. Direct-expansion coils shall be designed and tested in accordance with ASHRAE Std 15 Safety Code for Mechanical Refrigeration.
D. Insulation and insulation adhesive shall comply with NFPA 90A requirements or flame spread and smoke generation.
E. Unit shall be rated for sound performance in accordance with AHRI 260 and AMCA 300.
F. Unit shall be provided to comply with the maximum allowable fan horsepower per ICC (IECC) and ASHRAE Std 90.1 I-P.
1.05 GENERAL DESCRIPTION
A. Indoor mounted, central station air handling unit designed to provide air to a conditioned space as required to meet specified performance requirements for ventilation, heating, cooling, filtration, and distribution. Unit shall be assembled for horizontal/vertical application and arranged to discharge conditioned air as shown on the drawings. Units shall be supplied by the specified manufacturer.

1.06 SUBMITTALS
A. Submit shop drawings and product data under provisions of Division One.
B. Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.
C. Product data shall indicate dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, and gauges and finishes of materials.
D. Provide fan curves with specified operating point clearly plotted.
E. Submit product data of filter media, filter performance data, filter assembly, and filter frames.
F. Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory installed and field installed wiring.
G. Submit manufacturer’s installation instructions under provisions of Division One.
H. Submit operation and maintenance data under provisions of Section 23 02 00.
I. Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

1.07 DELIVERY, STORAGE AND HANDLING
A. Unit shall be stored and handled in accordance with the unit manufacturer’s instructions.

1.08 ENVIRONMENTAL REQUIREMENTS
A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, and fan has been test-run under observation.

1.09 OPERATIONS PERSONNEL TRAINING
A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
1. Purpose of equipment.
2. Principle of how the equipment works.
3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions.
5. Most likely failure modes, causes and corrections.
6. On site demonstration.

PART 2 - PRODUCTS
2.01 ACCEPTABLE MANUFACTURERS
A. Carrier: Model 39M
B. Trane: Performance Climate Changer
C. JCI: Solution
D. Daikin: Vision
E. Temtrol: ITF or WF
F. Substitutions: Under provisions of Division One.

2.02 GENERAL DESCRIPTION
A. Unit shall be factory supplied, central station air handler suitable for the capacities and configurations as shown on drawings. Unit may consist of a fan and coil section with a factory installed chilled water or direct-expansion coil, heating coil section, electric heat section, face and bypass section, filter section, access section, mixing box or combination filter-mixing box, return fan, diffuser, or air blender as indicated on the drawings.
2.03 CASING

A. All unit sections shall be supplied with 12 gauge galvanized steel structural perimeter base rail. Condensate drain connection will not penetrate the base rail. If external isolators are not used, provide 6 inch minimum height housekeeping pads or sufficient overall height to provide p-trap with 1 inch greater that unit total static pressure.

B. Unit panels for all sections shall be double wall construction and shall be constructed of minimum 18 gauge G90 mill galvanized steel. Casing panels shall be fully removable for easy access to the unit, and shall be secured to structural frame with aluminized or cadmium plated screws. Removal of panels must not affect the structural integrity of the unit. All panels shall have a minimum of 2-inch thick foam insulation (R-13). All panels shall be completely gasketed prior to shipping.

C. Casing air leakage shall not exceed Leakage Class 6 per ASHRAE Std 111 at +/- 8" w.g. Engineer shall select one (1) unit at their discretion, to test in the field (manufacturer to carry leakage test cost for 1 unit). The selected unit shall be tested and documented to leak no more than 1% unit design flow at +/- 8" w.g. Specified air leakage shall be accomplished without the use of caulk. Total estimated air leakage shall be reported for each unit in CFM, as a percentage of supply air, and as an ASHRAE Std 111 Leakage Class in the submittal. Unit casing (wall/floor/roof panels and doors) shall be able to withstand up to 1.5 times design static pressure, or 8" w.g., whichever is less, and shall not exceed 0.0042" per inch of panel span (L/240). Floor panels shall be double-wall construction and designed to support a 250 lb. load during maintenance activities and shall deflect no more than 0.0042" per inch of panel span.

D. Double wall hinged removable access doors with multiple handles shall be provided in the fan and filter sections on the drive side of the unit. Access doors must also be provided in all sections where the removal of sheet metal screws is required for unit access. Doors shall be of the same thickness and construction as the wall panels. A gasket shall be provided around the entire door perimeter.

2.04 FANS

A. Units shall be provided with direct-driven, single-width, single-inlet (SWSI) airfoil plenum fans constructed per AMCA requirements for the duty specified. Class I fans are not acceptable. Fan wheels shall be aluminum construction and rated in accordance with and certified by AMCA 210. All fans shall be selected to deliver the specified airflow quantity at the specified operating Total Static Pressure and specified fan/motor speed. The fan shall be selected to operate at a system Total Static Pressure that does not exceed 90% of the specified fan’s peak static pressure producing capability at the specified fan/motor speed. Each fan/motor assembly shall include a minimum 14 gauge spun steel fan inlet funnel, and a G90 galvanized steel motor support plate and fan base with internal vibration isolation.

B. Units delivering supply airflow rates of significant magnitude shall be equipped with multiple supply fans in an array configuration. Refer to scheduled values to verify motor quantity per unit. Where multiple fans are provided, backdraft dampers shall be mounted upstream of each fan for isolation and a single source power motor control panel shall be factory installed. All fans shall be factory-wired to motor control panel which shall consist of individual motor overload relays and on-off disconnect switch for power isolation.

C. All motors shall be premium efficiency, totally enclosed fan-cooled (TEFC), selected at the specified operating voltage, RPM, and efficiency as specified or as scheduled elsewhere. Motors shall meet the requirements of NEMA MG 1 Part 30 and 31, section 4.4.2. Motor HP shall not exceed the scheduled HP as indicated in the AHU equipment schedules.

2.05 COILS

A. All coils shall be tested at 300 psig air pressure, under water.

B. All coils shall be installed on tracks for easy removal from the air handling unit. Units that require disassembly of the unit for coil removal are not acceptable.
C. Coils shall be aluminum plate fin type with belled collars and shall be bonded to 1/2 inch or 5/8 inch OD copper tubes by mechanical expansion. Coils shall have headers with steel MPT connections. Working pressure shall be 250 psig at 300 degreesF.

D. Coils shall be drainable and have non-trapping circuits. Headers shall have drain and vent connections extended to the outside of the unit casing. Supply and return headers shall be clearly labeled on the outside of the unit. Provide grommets at all pipe penetrations through cabinet.

E. Main drain pan shall be double wall stainless steel with minimum 2 inch insulation, sloped toward drain fitting, with integral elbow for side discharge and FPT connection, and shall comply with ASHRAE Std 62.1. A maximum of one drain shall be supplied for each cooling coil section which shall extend at least 18” downstream of the coil. The unit design shall not require a drain pan in any downstream section to contain the coil condensate. Moisture shall not carry over past the coil. Moisture eliminators are not acceptable for moisture carryover prevention.

F. Direct expansion coils shall be furnished with a brass distributor with solder type connections. Suction and discharge connections shall be on the same end regardless of rows deep. Coils shall have intertwined circuits for equal operation on each circuit.

G. Maximum face velocity across cooling coils shall be 500 FPM, unless noted otherwise on equipment schedule.

H. Coils in series shall have a minimum of 12-inch space between coil casings.

2.06 FILTERS
A. Filter section shall accept 2 inch or 4 inch filters of standard sizes as indicated on drawings and shall be designed and constructed to house the type of filter specified. Section shall include side access slide rails.

B. A magnahelic differential pressure gauge shall be factory installed and flush mounted on drive side to measure the pressure drop across the filter.

2.07 ACCESSORIES
A. Mixing boxes and filter mixing boxes sections shall have opposed blades and interconnecting outside air and return air dampers. All mixing boxes shall have a double wall hinged access door on the drive side of the unit.

B. Face and bypass sections shall have opposed acting damper blades.

C. All damper blades shall be galvanized steel, double skin airfoil type, housed in a galvanized steel frame and mechanically fastened to a hex axle rod rotating in stainless steel bearings. Dampers shall be sectionalized to limit blade length to no more than 48 inches so as to minimize blade warpage. Blade seals are required to assure tight closure. The damper shall be rated for a maximum leakage rate of 1 percent of nominal airflow at 1 inch w.g.

D. Access sections shall be installed where indicated on the drawings and shall have a double walled hinged door.

E. Diffuser sections shall consist of casing as specified with an integral perforated aluminum plate placed on the discharge side of the supply fan to ensure even and uniform air distribution over the adjacent downstream component. Diffuser section is required if a filter section is directly following the fan.

PART 3 - EXECUTION

3.01 INSTALLATION
A. If floor mounted air handling units are furnished with internal vibration isolation option, provide 2” thick Amber/Booth type NRC ribbed neoprene pads or approved equal to address high frequency breakout and provide additional unit elevation with overall sufficient height to provide p-trap with one inch greater than the unit total static pressure. Ribbed neoprene pads shall be located in accordance with the air handling unit manufacturer’s recommendations. Condensate drain connection shall not penetrate the base air handling unit’s rail.

B. Install in accordance with manufacturer’s instructions.
C. All items required for a complete and proper installation are not necessarily indicated on the plans or in the specifications. Provide all items required as per manufacturer’s requirements.

END OF SECTION
SECTION 23 82 19

FAN COIL UNIT

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
   B. Section 23 02 00 - Basic Materials and Methods for HVAC shall be included as a part of this Section as though written in full in this document.

1.02 SCOPE
   A. Scope of the Work shall include the furnishing and complete installation of the equipment covered by this Section, with all auxiliaries, ready for owner's use.

1.03 REFERENCES
   A. AHRI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment.
   C. AHRI 430 (I-P) - Performance Rating of Central Station Air-Handling Units.

1.04 WARRANTY
   A. Provide entire unit with parts and labor warranty by the equipment manufacturer for one year from start-up or 18 months from date received on site.
   B. For units with DX coils, provide all components of the refrigeration circuit with parts and labor warranty by the equipment manufacturer for five years.

1.05 OPERATIONS PERSONNEL TRAINING
   A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject system/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:
      1. Purpose of equipment.
      2. Principle of how the equipment works.
      3. Important parts and assemblies.
      4. How the equipment achieves its purpose and necessary operating conditions.
      5. Most likely failure modes, causes and corrections.
      6. On site demonstration.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS
   A. Carrier
   B. JCI/York
   C. Trane
   D. AAON
   E. Daikin

2.02 FAN COIL UNITS
   A. Fan coil units shall be factory built, manufactured as scheduled on Drawings. Contractor shall field verify exact clearances required for fan coil units. Units shall be field located as required and shop drawings shall indicate final location for approval by Architect/Engineer.
   B. Furnish and install fan coil units of the type, capacities, ratings and drive motor horsepower shown on the Drawings.
   C. Units shall be factory fabricated, draw-thru type, and shall have fan section, cooling coil section, condensate drain pan, adjustable blower drive with motor on resilient mounted base, vee-belts with guard, filter section, and mixing box (if scheduled) assembled as integrated fan coil units.
D. Units shall be tested and certified with AHRI 430 (I-P) and testing in accordance with AHRI 260.

E. REQUIREMENTS:

1. Mill-galvanized steel, rigidly framed, braced, and reinforced; access panels each side of unit; minimum panel ga. - 18; minimum weight formed framing member 14 ga.

2. Fan section, cooling coil section, and outlet frame throats shall be internally insulated at the factory with 1” thick, 1-1/2 PCF density, Neoprene coated fiberglass cemented in place with waterproof adhesive, having fire-retardant characteristics in accordance with NFPA 90A.

3. Drain pan shall not be lighter than 14 ga.; extend completely under the coil section and be all-galvanized, foam insulated pan with drain connections.

4. When the fan coil unit is installed above an accessible ceiling, the unit shall incorporate a secondary drain pan. The secondary pan shall be fabricated from galvanized sheet metal, 16 gauge minimum with cross breaking sloped towards a drain. The sides shall be a minimum 2” tall and the corners shall be soldered watertight. The top edge shall have a 1/4” hem to provide additional rigidity and the secondary pan shall be supported at a minimum of six points. The pan shall extend on all sides a minimum of 3” beyond the sides of the unit casing. Route the secondary drain piping to a conspicuous location, or install a float switch at the low point in the secondary pan. The secondary pan should be sloped a minimum of 1/8” per foot and supported so that the unit is not in contact with the bottom of the secondary pan.

5. The fan section, including wheels, shafts, bearings, drive, etc., shall be statically and dynamically balanced as an assembly, and the shaft shall not pass through the first critical speed, while accelerating from rest to operating speed. Submittal data shall state the first critical shaft speed. Shaft bearings shall be of vacuum de-gassed steel, and shall be selected for 200,000 hours average life.

6. Coil shall be as hereinafter specified.

2.03 COILS

A. Cooling coils shall be cartridge type and, when mounted in fan coil units, shall be removable from either end. Coils shall be constructed of copper tubes with aluminum fins and shall be designed for even distribution of air across the face of the coils; air shall not pass around coil frames: Coils shall have same end connection for DX or chilled water piping.

B. Maximum face velocity across cooling coils shall be 500 FPM, unless noted otherwise on schedule.

C. Coil performance data shall be in accordance with the current edition of AHRI 410.

PART 3 - EXECUTION

3.01 INSTALLATION

A. All HVAC equipment shall be installed as per manufacturer's printed installation instructions.

B. All items required for a complete and proper installation are not necessarily indicated on the Drawings or in the Specifications. Provide all items required as per manufacturer’s requirements.

END OF SECTION
SECTION 26 02 00

BASIC MATERIALS AND METHODS FOR ELECTRICAL

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions and Supplementary Conditions apply to all Work herein.

B. The Contract Drawings indicate the extent and general arrangement of the systems. If any departure from the Contract Drawings are deemed necessary by the Contractor, details of such departures and the reasons therefore, shall be submitted to the Architect for approval as soon as practicable. No such departures shall be made without the prior written approval of the Architect.

1.02 SCOPE OF WORK

A. The Work included under this Contract consists of the furnishing and installation of all equipment and material necessary and required to form the complete and functioning systems in all of its various phases, all as shown on the accompanying Drawings and/or described in these Specifications. The contractor shall review all pertinent drawings, including those of other contracts prior to commencement of Work.

B. This Division requires the furnishing and installing of all items Specified herein, indicated on the Drawings or reasonably inferred as necessary for safe and proper operation; including every article, device or accessory (whether or not specifically called for by item) reasonably necessary to facilitate each system’s functioning as indicated by the design and the equipment specified. Elements of the work include, but are not limited to, materials, labor, supervision, transportation, storage, equipment, utilities, all required permits, licenses and inspections. All work performed under this Section shall be in accordance with the Project Manual, Drawings and Specifications and is subject to the terms and conditions of the Contract.

C. The approximate locations of Electrical items are indicated on the Drawings. These Drawings are not intended to give complete and accurate details in regard to location of outlets, apparatus, etc. Exact locations are to be determined by actual measurements at the building, and will in all cases be subject to the Review of the Owner or Engineer, who reserves the right to make any reasonable changes in the locations indicated without additional cost to the Owner.

D. Items specifically mentioned in the Specifications but not shown on the Drawings and/or items shown on Drawings but not specifically mentioned in the Specifications shall be installed by the Contractor under the appropriate section of work as if they were both specified and shown.

E. All discrepancies within the Contract Documents discrepancies between the Contract Documents and actual job-site conditions shall be reported to the Owner or Engineer so that they will be resolved prior to the bidding, where this cannot be done at least 7 working days prior to bid; the greater or more costly of the discrepancy shall be bid. All labor and materials required to perform the work described shall be included as part of this Contract.

F. It is the intention of this Section of the Specifications to outline minimum requirements to furnish the Owner with a turn-key and fully operating system in cooperation with other trades.

G. It is the intent of the above "Scope" to give the Contractor a general outline of the extent of the Work involved; however, it is not intended to include each and every item required for the Work. Anything omitted from the "Scope" but shown on the Drawings, or specified later, or necessary for a complete and functioning heating, ventilating and air conditioning system shall be considered a part of the overall "Scope".

H. The Contractor shall rough-in fixtures and equipment furnished by others from rough-in and placement drawings furnished by others. The Contractor shall make final connection to fixtures and equipment furnished by others.

I. Contractor shall participate in the commissioning process; including but not limited to meeting attendance, completion of checklists and participation in functional testing.
1.03 RELATED SECTIONS
   A. General Conditions
   B. Supplementary Conditions
   C. Division One

1.04 COOPERATION WITH TRADES:
   A. Cooperation with trades of adjacent, related, or affected materials or operations shall be considered a part of this work in order to affect timely and accurate placing of work and bring together in proper and correct sequence, the work of such trades.

1.05 REFERENCES
   A. National Electrical Code (NEC)
   B. American Society for Testing and Materials (ASTM)
   C. Underwriter's Laboratories, Inc. (UL)
   D. Insulated Cable Engineer's Association (ICEA).
   E. National Electrical Manufacturer's Association (NEMA).
   F. Institute of Electrical and Electronic's Engineers (IEEE).
   H. National Fire Protection Association (NFPA).

1.06 COMPLETE FUNCTIONING OF WORK:
   A. All work fairly implied as essential to the complete functioning of the electrical systems shown on the Drawings and Specifications shall be completed as part of the work of this Division unless specifically stated otherwise. It is the intention of the Drawings and Specifications to establish the types of the systems, but not set forth each item essential to the functioning of the system. In case of doubt as to the work intended, or in the event of amplification or clarification thereof, the Contractor shall call upon the Architect for supplementary instructions, Drawings, etc.
   B. Contractor shall review all pertinent Drawings and adjust his work to all conditions shown there on. Discrepancies between Plans, Specifications, and actual field conditions shall be brought to the prompt attention of the Architect.
      1. Approximate location of transformers, feeders, branch circuits, outlets, lighting and power panels, outlets for special systems, etc., are indicated on the Drawings. However, the Drawings, do not give complete and accurate detailed locations of such outlets, conduit runs, etc., and exact locations must be determined by actual field measurement. Such locations will, at all times, be subject to the approval of the Architect.
      2. Communicate with the Architect and secure his approval of any outlet (light fixture, receptacle, switch, etc.) location about which there may be the least question. Outlets obviously placed in a location not suitable to the finished room or without specific approval, shall be removed and relocated when so directed by the Architect. Location of light fixtures shall be coordinated with reflected ceiling plans.
   C. Additional coordination with mechanical contractor may be required to allow adequate clearances of mechanical equipment, fixtures and associated appurtenances. Contractor to notify Architect and Engineer of unresolved clearances, conflicts or equipment locations.

1.07 SCHEMATIC NATURE OF CONTRACT DOCUMENTS
   A. The contract documents are schematic in nature in that they are only to establish scope and a minimum level of quality. They are not to be used as actual working construction drawings. The actual working construction drawings shall be the approved shop drawings.

1.08 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, and 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.

3. Perform work by persons qualified to produce workmanship of specified quality. Persons performing electrical work shall be required to be licensed. Onsite supervision, journeyman shall have minimum of journeyman license. Helpers, apprentices shall have minimum of apprentice license.

1.09 DATE OF FINAL ACCEPTANCE

A. The date of final acceptance shall be the date of owner occupancy, or the date all punch list items have been completed or final payment has been received. Refer to Division One for additional requirements.

B. The date of final acceptance shall be documented in writing and signed by the architect, owner and contractor.

1.10 DEFINITIONS AND SYMBOLS

A. General Explanation: A substantial amount of construction and Specification language constitutes definitions for terms found in other Contract Documents, including Drawings which must be recognized as diagrammatic and schematic in nature and not completely descriptive of requirements indicated thereon. Certain terms used in Contract Documents are defined generally in this article, unless defined otherwise in Division 1.

B. Definitions and explanations of this Section are not necessarily either complete or exclusive, but are general for work to the extent not stated more explicitly in another provision of the Contract Documents.

C. Indicated: The term "Indicated" is a cross-reference to details, notes or schedules on the Drawings, to other paragraphs or schedules in the Specifications and to similar means of recording requirements in Contract Documents. Where such terms as "Shown", "Noted", "Scheduled", "Specified" and "Detailed" are used in lieu of "Indicated", it is for the purpose of helping the reader locate cross-reference material, and no limitation of location is intended except as specifically shown.

D. Directed: Where not otherwise explained, terms such as "Directed", "Requested", "Accepted", and "Permitted" mean by the Architect or Engineer. However, no such implied meaning will be interpreted to extend the Architect's or Engineer's responsibility into the Contractor's area of construction supervision.

E. Reviewed: Where used in conjunction with the Engineer's response to submittals, requests for information, applications, inquiries, reports and claims by the Contractor the meaning of the term "Reviewed" will be held to limitations of Architect's and Engineer's responsibilities and duties as specified in the General and Supplemental Conditions. In no case will "Reviewed" by Engineer be interpreted as a release of the Contractor from responsibility to fulfill the terms and requirements of the Contract Documents.

F. Furnish: Except as otherwise defined in greater detail, the term "Furnish" is used to mean supply and deliver to the project site, ready for unloading, unpacking, assembly, installation, etc., as applicable in each instance.

G. Install: Except as otherwise defined in greater detail, the term "Install" is used to describe operations at the project site including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance.

H. Provide: Except as otherwise defined in greater detail, the term "Provide" is used to mean "Furnish and Install", complete and ready for intended use, as applicable in each instance.

I. Installer: Entity (person or firm) engaged by the Contractor or its subcontractor or Subcontractor for performance of a particular unit of work at the project site, including unloading, unpacking, assembly, erection, placing, anchoring, applying, working to dimension, finishing, curing, protection, cleaning and similar operations, as applicable in each instance. It is a general requirement that such entities (Installers) be expert in the operations they are engaged to perform.

J. Imperative Language: Used generally in Specifications. Except as otherwise indicated, requirements expressed imperatively are to be performed by the Contractor. For clarity of reading at certain locations, contrasting subjective language is used to describe
responsibilities that must be fulfilled indirectly by the Contractor, or when so noted by other identified installers or entities.

K. Minimum Quality/Quantity: In every instance, the quality level or quantity shown or specified is intended as minimum quality level or quantity of work to be performed or provided. Except as otherwise specifically indicated, the actual work may either comply exactly with that minimum (within specified tolerances), or may exceed that minimum within reasonable tolerance limits. In complying with requirements, indicated or scheduled numeric values are either minimums or maximums as noted or as appropriate for the context of the requirements. Refer instances of uncertainty to Owner or Engineer via a request for information (RFI) for decision before proceeding.

L. Abbreviations and Symbols: The language of Specifications and other Contract Documents including Drawings is of an abbreviated type in certain instances, and implies words and meanings which will be appropriately interpreted. Actual word abbreviations of a self-explanatory nature have been included in text of Specifications and Drawings. Specific abbreviations and symbols have been established, principally for lengthy technical terminology and primarily in conjunction with coordination of Specification requirements with notations on Drawings and in Schedules. These are frequently defined in Section at first instance of use or on a Legend and Symbol Drawing. Trade and industry association names and titles of generally recognized industry standards are frequently abbreviated. Singular words will be interpreted as plural and plural words will be interpreted as singular where applicable and where full context of Contract Documents so indicate. Except as otherwise indicated, graphic symbols and abbreviations used on Drawings and in Specifications are those recognized in construction industry for indicated purposes. Where not otherwise noted symbols and abbreviations are defined by 1993 ASHRAE Fundamentals Handbook, chapter 34 "Abbreviations and Symbols", ASME and ASPE published standards.

1.11 DELIVERY, STORAGE, AND HANDLING
A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
B. Deliver products to the project at such time as the project is ready to receive the equipment, pipe or duct properly protected from incidental damage and weather damage.
C. Damaged equipment shall be promptly removed from the site and new, undamaged equipment shall be installed in its place promptly with no additional charge to the Owner.

1.12 SUBMITTALS
A. Coordinate with Division 01 for submittal timetable requirements, unless noted otherwise within thirty (30) days after the Contract is awarded. The Contractor shall submit an electronic copy of a complete set of shop drawings and complete data covering each item of equipment or material. The submittal of each item requiring a submittal must be received by the Architect or Engineer within the above thirty day period. The Architect or Engineer shall not be responsible for any delays or costs incurred due to excessive shop drawing review time for submittals received after the thirty (30) day time limit. The Architect and Engineer will retain a copy of all shop drawings for their files. All literature pertaining to items subject to Shop Drawing submittal shall be submitted at one time. Submittals shall be placed in one electronic file in PDF 8.0 format and bookmarked for individual specification sections. Individual electronic files of submittals for individual specifications shall not be permitted. Each submittal shall include the following items:
1. A cover sheet with the names and addresses of the Project, Architect, MEP Engineer, General Contractor and the Subcontractor making the submittal. The cover sheet shall also contain the section number covering the item or items submitted and the item nomenclature or description.
2. An index page with a listing of all data included in the Submittal.
3. A list of variations page with a listing all variations, including unfurnished or additional required accessories, items or other features, between the submitted equipment and the specified equipment. If there are no variations, then this page shall state "NO VARIATIONS". Where variations affect the work of other Contractors, then the Contractor shall certify on this page that these variations have been fully coordinated with the affected Contractors and that all expenses associated with the variations will be paid by the submitting Contractor. This page will be signed by the submitting Contractor.
4. Equipment information including manufacturer's name and designation, size, performance and capacity data as applicable. All applicable Listings, Labels, Approvals and Standards shall be clearly indicated.

5. Dimensional data and scaled drawings as applicable to show that the submitted equipment will fit the space available with all required Code and maintenance clearances clearly indicated and labeled at a minimum scale of 1/4" = 1'-0", as required to demonstrate that the alternate or substituted product will fit in the space available.

6. Identification of each item of material or equipment matching that indicated on the Drawings.

7. Sufficient pictorial, descriptive and diagrammatic data on each item to show its conformance with the Drawings and Specifications. Any options or special requirements or accessories shall be so indicated. All applicable information shall be clearly indicated with arrows or another approved method.

8. Additional information as required in other Sections of this Division.

9. Certification by the General Contractor and Subcontractor that the material submitted is in accordance with the Drawings and Specifications, signed and dated in long hand. Submittals that do not comply with the above requirements shall be returned to the Contractor and shall be marked "REVISE AND RESUBMIT".

B. Refer to Division 1 for additional information on shop drawings and submittals.

C. Equipment and materials submittals and shop drawings will be reviewed for compliance with design concept only. It will be assumed that the submitting Contractor has verified that all items submitted can be installed in the space allotted. Review of shop drawings and submittals shall not be considered as a verification or guarantee of measurements or building conditions.

D. Where shop drawings and submittals are marked "REVIEWED", the review of the submittal does not indicate that submittals have been checked in detail nor does it in any way relieve the Contractor from his responsibility to furnish material and perform work as required by the Contract Documents.

E. Shop drawings shall be reviewed and returned to the Contractor with one of the following categories indicated:

1. REVIEWED: Contractor need take no further submittal action, shall include this submittal in the O&M manual and may order the equipment submitted on.

2. REVIEWED AS NOTED: Contractor shall submit a letter verifying that required exceptions to the submittal have been received and complied with including additional accessories or coordination action as noted, and shall include this submittal and compliance letter in the O&M manual. The contractor may order the equipment submitted on at the time of the returned submittal providing the Contractor complies with the exceptions noted.

3. NOT APPROVED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is not approved, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or drawings. Contractor shall not order equipment that is not approved. Repetitive requests for substitutions will not be considered.

4. REVISE AND RESUBMIT: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked revise and resubmit, the Contractor will automatically be required to furnish the product, material or method named in the Specifications and/or drawings. Contractor shall not order equipment marked revise and resubmit. Repetitive requests for substitutions will not be considered.

5. CONTRACTOR'S CERTIFICATION REQUIRED: Contractor shall resubmit submittal on material, equipment or method of installation. The Contractor's stamp is required stating the submittal meets all conditions of the contract documents. The stamp shall be signed by the General Contractor. The submittal will not be reviewed if the stamp is not placed and signed on all shop drawings.

6. MANUFACTURER NOT AS SPECIFIED: Contractor shall resubmit new submittal on material, equipment or method of installation when the alternate or substitute is marked manufacturer not as specified, the Contractor will automatically be required to furnish the product, material or method named in the specifications. Contractor shall not order equipment where submittal is marked manufacturer not as specified.
Repetitive requests for substitutions will not be considered.

F. Materials and equipment which are purchased or installed without shop drawing review shall be at the risk of the Contractor and the cost for removal and replacement of such materials and equipment and related work which is judged unsatisfactory by the Owner or Engineer for any reason shall be at the expense of the Contractor. The responsible Contractor shall remove the material and equipment noted above and replace with specified equipment or material at his own expense when directed in writing by the Architect or Engineer.

G. Shop Drawing Submittals shall be complete and checked prior to submission to the Engineer for review.

H. Furnish detailed shop drawings, descriptive literature, table of contents listing all items being submitted at the beginning of each submittal package, physical data and a specification critique for each section indicating "compliance" and/or "variations" for the following items:
   1. Distribution Panelboards
   2. Panelboards
   3. Wiring Gutters
   4. Heavy Duty Disconnect Switches
   5. Lighting Fixtures
   6. Lighting Contactors
   7. Time Clocks
   8. Lighting Control System
   9. Photocells
   10. Wiring Devices and Plates
   11. Conduit and Fittings
   12. Wire
   13. General Purpose Dry Type Transformers
   14. Harmonic Mitigating Type Transformers
   15. Emergency Generator
   16. Automatic Transfer Switches
   17. Sound Reinforcing System
   18. Fire Alarm System
   19. Surge Protection Device (SPD)
   20. Lightning Protection

I. Refer to each specification section for additional requirements.

1.13 OPERATION AND MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 and in addition to the requirements specified in Division 1, include the following information for equipment items:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Servicing instructions and lubrication charts and schedules.

1.14 COORDINATION DRAWINGS

A. Prepare coordination drawings to a scale of 1/4”=1'-0" or larger; detailing major elements, components, and systems of mechanical equipment and materials in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
   1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
      a. Wall and type locations.
b. Clearances for installing and maintaining insulation.
c. Locations of light fixtures and sprinkler heads.
d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
e. Equipment connections and support details.
f. Exterior wall and foundation penetrations.
g. Routing of storm and sanitary sewer piping.
h. Fire-rated wall and floor penetrations.
i. Sizes and location of required concrete pads and bases.
j. Valve stem movement.
k. Structural floor, wall and roof opening sizes and details.

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

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

4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

B. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.

C. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

1.15 RECORD DRAWINGS

A. Maintain a continuous record during the course of construction of all changes and deviations in the work from the contract drawings. Upon completion of the work, purchase a set of "Auto Positive Tracings" on vellum and make corrections as required to reflect the electrical systems as installed. Location and size of all conduit shall be accurately shown to dimension. Submit three prints of the tracings for approval. Make corrections to tracings as directed and deliver "Auto Positive Tracings" to the Architect. Record drawings shall be furnished in addition to shop drawings. Symbols on the Record drawings shall correspond to the identification symbols on the contract drawings and equipment identification plates and tags.

B. The Contractor shall maintain a set of clearly marked black line record "AS-BUILT" prints on the job site on which he shall mark all work details, alterations to meet site conditions and changes made by "Change Order" notices. These shall be kept available for inspection by the Owner, Architect or Engineer at all times.

C. Refer to Division 1 for additional requirements concerning record drawings. If the Contractor does not keep an accurate set of as-built drawings, the pay request may be altered or delayed at the request of the Architect. Mark the drawings with a colored pencil. Delivery of as-built prints and reproducibles is a condition of final acceptance.

D. The record prints shall be updated on a daily basis and shall indicate accurate dimensions for all buried or concealed work, precise locations of all concealed pipe or duct, locations of all concealed valves, controls and devices and any deviations from the work shown on the Construction Documents which are required for coordination. All dimensions shall include at least two dimensions to permanent structure points.

E. Submit three prints of the tracings for approval. Make corrections to tracings as directed and delivered "Auto Positive Tracings" to the architect. "As-Built" drawings shall be furnished in addition to shop drawings.

F. When the option described in paragraph F., above is not exercised then upon completion of the work, the Contractor shall transfer all marks from the submit a set of clear concise set of reproducible record "AS-BUILT" drawings and shall submit the reproducible drawings with corrections made by a competent draftsman and three (3) sets of black line prints to the Architect or Engineer for review prior to scheduling the final inspection at the
 completion of the work. The reproducible record "AS-BUILT" drawings shall have the Engineers Name and Seal removed or blanked out and shall be clearly marked and signed on each sheet as follows:

CERTIFIED RECORD DRAWINGS

G. DATE:
(NAME OF GENERAL CONTRACTOR)
BY: __________________________
(SIGNATURE)
(NAME OF SUBCONTRACTOR)
BY: __________________________
(SIGNATURE)

1.16 CERTIFICATIONS AND TEST REPORTS

A. Submit a detailed schedule for completion and testing of each system indicating scheduled dates for completion of system installation and outlining tests to be performed and schedule date for each test. This detailed completion and test schedule shall be submittal at least 90 days before the projected Project completion date.

B. Test result reporting forms shall be submitted for review no later than the date of the detailed schedule submitted.

C. Submit 4 copies of all certifications and test reports to the Architect or Engineer for review adequately in advance of completion of the Work to allow for remedial action as required to correct deficiencies discovered in equipment and systems.

D. Certifications and test reports to be submitted shall include, but not be limited to those items outlined in Section of Division 26.

1.17 MAINTENANCE MANUALS

A. Coordinate with Division 1 for maintenance manual requirements, unless noted otherwise bind together in "D ring type" binders by National model no. 79-883 or equal, binders shall be large enough to allow 1/4" of spare capacity. Three (3) sets of all approved shop drawing submittals, fabrication drawings, bulletins, maintenance instructions, operating instructions and parts exploded views and lists for each and every piece of equipment furnished under this Specification. All sections shall be typed and indexed into sections and labeled for easy reference and shall utilize the individual specification section numbers shown in the Electrical Specifications as an organization guideline. Bulletins containing information about equipment that is not installed on the project shall be properly marked up or stripped and reassembled. All pertinent information required by the Owner for proper operation and maintenance of equipment supplied by Division 26 shall be clearly and legibly set forth in memoranda that shall, likewise, be bound with bulletins.

B. Prepare maintenance manuals in accordance with Special Project Conditions, in addition to the requirements specified in Division 26, include the following information for equipment items:

1. Identifying names, name tags designations and locations for all equipment.
2. Fault Current calculations and Coordination Study.
3. Reviewed shop drawing submittals with exceptions noted compliance letter.
4. Fabrication drawings.
5. Equipment and device bulletins and data sheets clearly highlighted to show equipment installed on the project and including performance curves and data as applicable, i.e., description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and model numbers of replacement parts.
6. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
7. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions, servicing instructions and lubrication charts and schedules.
8. Equipment name plate data.
10. Exploded parts views and parts lists for all equipment and devices.
11. Color coding charts for all painted equipment and conduit.
12. Location and listing of all painted parts and special keys and tools furnished to the Owner.
13. Furnish recommended lubrication schedule for all required lubrication points with listing of type and approximate amount of lubricant required.

C. Refer to Division 1 for additional information on Operating and Maintenance Manuals.

D. Operating and Maintenance Manuals shall be turned over to the Owner or Engineer a minimum of 14 working days prior to the beginning of the operator training period.

1.18 OPERATOR TRAINING

A. The Contractor shall furnish the services of factory trained specialists to instruct the Owner's operating personnel. The Owner's operator training shall include 12 hours of onsite training in three 4 hour shifts.

B. Before proceeding with the instruction of Owner Personnel, prepare a typed outline in triplicate, listing the subjects that will be covered in this instruction, and submit the outline for review by the Owner. At the conclusion of the instruction period obtain the signature of each person being instructed on each copy of the reviewed outline to signify that he has a proper understanding of the operation and maintenance of the systems and resubmit the signed outlines.

C. Refer to other Division 26 Sections for additional Operator Training requirements.

1.19 SITE VISITATION

A. Visit the site of the proposed construction in order to fully understand the facilities, difficulties and restriction attending the execution of the work.

B. Before submitting a bid, it will be necessary for each Contractor whose work is involved to visit the site and ascertain for himself the conditions to be met therein in installing his work and make due provision for same in his bid. It will be assumed that this Contractor in submitting his bid has visited the premises and that his bid covers all work necessary to properly install the equipment shown. Failure on the part of the Contractor to comply with this requirement shall not be considered justification for the omission or faulty installation of any work covered by these Specifications and Drawings.

C. Understand the existing utilities from which services will be supplied; verify locations of utility services, and determine requirements for connections.

D. Determine in advance that equipment and materials proposed for installation fit into the confines indicated.

1.20 WARRANTY

A. The undertaking of the work described in this Division shall be considered equivalent to the issuance, as part of this work, of a specific guarantee extending one year beyond the date of completion of work and acceptance by Owner, against defects in materials and workmanship. Materials, appliances and labor necessary to effect repairs and replacement so as to maintain said work in good functioning order shall be provided as required. Replacements necessitated by normal wear in use or by Owner's abuse are not included under this guarantee.

B. All normal and extended warranties shall include parts, labor, miscellaneous materials, travel time, incidental expenses, freight/shipping, refrigerant, oils, lubricants, belts, filters and any expenses related to service call required to diagnose warranty problems.

1.21 TRANSFER OF ELECTRONIC FILES

A. Project documents are not intended or represented to be suitable for reuse by Architect/Owner or others on extensions of this project or on any other project. Any such reuse or modification without written verification or adaptation by Engineer, as appropriate for the specific purpose intended, will be at Architect/Owner’s risk and without liability or legal exposure to Engineer or its consultants from all claims, damages, losses and expense, including attorney’s fees arising out of or resulting thereof.

B. Because data stored in electric media format can deteriorate or be modified inadvertently, or otherwise without authorization of the data’s creator, the party receiving the electronic
files agrees that it will perform acceptance tests or procedures within sixty (60) days of receipt, after which time the receiving party shall be deemed to have accepted the data thus transferred to be acceptable. Any errors detected within the sixty (60) day acceptance period will be corrected by the party delivering the electronic files. Engineer is not responsible for maintaining documents stored in electronic media format after acceptance by the Architect/Owner.

C. When transferring documents in electronic media format, Engineer makes no representations as to the long term compatibility, usability or readability of documents resulting from the use of software application packages, operating systems, or computer hardware differing from those used by Engineer at the beginning of the Project.

D. Any reuse or modifications will be Contractor's sole risk and without liability or legal exposure to Architect, Engineer or any consultant.

E. The Texas Board of Architectural Examiners (TBAE) has stated that it is in violation of Texas law for persons other than the Architect of record to revise the Architectural drawings without the Architect's written consent.

1. It is agreed that “MEP” hard copy or computer-generated documents will not be issued to any other party except directly to the Architect/Owner. The contract documents are contractually copyrighted and cannot be used for any other project or purpose except as specifically indicated in AIA B-141 Standard Form of Agreement Between Architect and Owner.

2. If the client, Architect or Owner of the project requires electronic media for “record purposes”, then AutoCAD/ Revit documents will be prepared by Engineer on electronic media such as removable memory devices, flash drives or CD's. These documents can also be submitted via file transfer protocols. AutoCAD/ Revit files will be submitted with all title block references intact to permit the end user to only view and plot the drawings. Revisions will not be permitted in this configuration.

3. At the Architect/Owner's request, Engineer will assist the Contractor in the preparation of the submittals and prepare one copy of AutoCAD/ Revit files on electronic media or submit through file transfer protocols. The electronic media will be prepared with all indica of documents ownership removed. The electronic media will be prepared in a "rvt" or "dwg" format to permit the end user to revise the drawings.

PART 2 - PRODUCTS

2.01 SUBSTITUTIONS

A. The names and manufacturers and model numbers have been used in the Contract documents to establish types of equipment and standards of quality. Where more than one manufacturer is named for a specific item of equipment, only one of the specified manufacturers will be considered for approval. Where only one manufacturer is mentioned with the phrase "or approved equal", Contractor may submit an alternate manufacturer for consideration, provided the following conditions are met:

1. Submit alternate equipment with complete descriptive data in shop drawing form. Provide sample of equipment upon request for review by Architect. Samples will be returned if requested in writing.

2. Alternate equipment must be equal from the standpoint of materials, construction and performance.

3. Alternate submittal must be presented to the Engineer/Architect ten (10) days prior to bid date for approval.

B. The Architect and Engineer shall be the sole judge of quality and equivalence of equipment, materials and methods.

2.02 PRODUCT LISTING

A. Products used on this project shall be listed by Underwriters' Laboratories.

2.03 ACCESS DOORS

A. Wherever access is required in walls or ceilings to concealed junction boxes, pull boxes, equipment, etc., installed under this Division, furnish a hinged access door and frame with flush latch handle to another Division for installation. Doors shall be as follows:

1. Plaster Surfaces: Milcor Style K.
2. Ceramic Tile Surfaces: Milcor Style M.
3. Drywall Surfaces: Milcor Style DW.
4. Install panels only in locations approved by the Architect.

2.04 EQUIPMENT PADS
A. Provide 4-inch-high concrete pads for indoor floor mounted equipment. Pads shall conform to the shape of the equipment with a minimum of 6 inch beyond the equipment. Top and sides of pads shall be troweled to a smooth finish, equivalent to the floor. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.
B. Provide 6-inch-high concrete pads for all exterior mounted equipment. Pads shall conform to the shape of the equipment with a minimum of 6 inch beyond the equipment. Provide a 4-foot monolithic extension to the pad in front of the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.) Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise.
C. Provide a minimum 6-inch-high, steel reinforced concrete pad for generators. Pads shall be sized 6" larger that the outside perimeter dimensions. Provide a 4-foot monolithic extension to the pad around the equipment for service when mounted on a non-finished area (i.e. landscape, gravel, clay, etc.). Refer to structural details. Top and sides of pads shall be troweled to a smooth finish. External corners shall be bullnosed to a 3/4" radius, unless shown otherwise. The generator shall be bolted to the concrete pad per the manufacturers details.
D. Provide steel reinforced concrete pad for utility transformers. Pads shall comply with Utility Company Standards.

2.05 ESCUTCHEONS
A. Provide heavy chrome or nickel plated plates, of approved pattern, on conduit passing through walls, floors and ceilings in finished areas. Where conduit passes through a sleeve, no point of the conduit shall touch the building construction. Caulk around such conduit with sufficient layers of two hour rated firesafing by Thermalfiber 4.0 P.C.F. density, U.S.G. fire test 4/11/78 and seal off openings between conduit and sleeves with non-hardening mastic prior to application of escutcheon plate. Escutcheons shall be Gravel Sure-Lock, or approved equal.

2.06 SPACE LIMITATIONS
A. Equipment shall be chosen which shall properly fit into the physical space provided and shown on the drawings, allowing ample room for access, servicing, removal and replacement of parts, etc. Adequate space shall be allowed for clearances in accordance with Code requirements. Physical dimensions and arrangement of equipment shall be subject to the approval of the Architect.

2.07 PAINTING
A. All factory assembled equipment for electrical work, except light fixtures, that normally is delivered with a factory applied finish shall be delivered with a hard surface factory applied finish such as baked-on machinery enamel which will not require additional field painting. The finish shall consist of not less than 2 coats of medium gray color paint USA No. 61 Munsell Notation 8-3G, 6. 10/0.54 enamel. This Contractor shall protect this finish from damage due to construction operations until acceptance of the building. He shall be responsible for satisfactorily restoring any such finishes or replacing equipment that becomes stained or damaged.

2.08 ELECTRICAL SYSTEM IDENTIFICATION
A. Conduit Systems: Provide adequate marking of major conduit which is exposed or concealed in accessible spaces to distinguish each run as either a power or signal/communication conduit. Except as otherwise indicated, use orange banding with black lettering. Provide self-adhesive or snap-on type plastic markers. Indicate voltage for that raceway. Locate markers at ends of conduit runs, on pull boxes, on junction boxes, near switches and other control devices, near items of equipment served by the conductors, at points where conduit passes through walls or floors, or enters non-accessible construction and at spacings of not more than 50 feet along each run of conduit. Switch-leg conduit and short branches for power connections do not have to be marked, except where conduit is larger than 3/4 inch. Branch circuit conduits, junction boxes and pull boxes shall be marked with a permanent marker indicating panel name and branch circuit numbers.
B. Underground Cable Identification: Bury a continuous, preprinted, bright colored plastic ribbon cable marker with each underground cable (or group of cables), regardless of whether conductors are in conduit, duct bank, or direct buried. Locate each directly over cables, 6 to 8 inches below finished grade.

C. Identification of Equipment:
1. All major equipment shall have a manufacturer’s label identifying the manufacturer’s address, equipment model and serial numbers, equipment size, and other pertinent data. Care shall be taken not to obliterate this nameplate in any way. Provide black back plate with white letters and numbers for normal equipment. Provide red back plate with white letters and numbers for optional emergency equipment. Provide yellow back plate with white letters and numbers for Life safety equipment.
2. A black-white-black laminated plastic engraved identifying nameplate shall be secured by stainless steel screws to each automatic transfer switch, switchboard, distribution panel, motor control center, motor starter panels and panelboards.
   a. Identifying nameplates shall have ¼ inch high engraved letters and shall contain the following information:
      1) Name
      2) Voltage
      3) Phase
      4) “3” or “4” wire, and
      5) Where it is fed from.
   b. An example of a panelboard nameplate is:
      Center Panel – 1HB
      480/277 volt, 3 phase, 4 wire
      Center Fed from DP2
   c. An example of an automatic transfer switch nameplate is:
      Center ATS #2
      480/277 volt, 3 phase, 4 wire, 4 pole
      Center Fed from MSB and DPE
3. Each feeder device in a switchboard, distribution panel, and motor control center device shall have a nameplate showing the load served in ½ inch high engraved letters.
4. A black-white-black laminated plastic engraved identifying nameplate shall be secured by screws to each safety switch, disconnect switch, individual motor starter, enclosed circuit breaker, wireway, and terminal cabinet.
   a. Identifying nameplates shall have 1/4 inch high engraved letters and shall indicate the equipment served.
   b. An example if a disconnect switch is: AHU-1.
5. Prohibited Markings: Markings which are intended to identify the manufacturer, vendor, or other source from which the material has been obtained are prohibited for installation within public, tenant, or common areas within the project. Also, prohibited are materials or devices which bear evidence that markings or insignias have been removed. Certification, testing (example, Underwriters’ Laboratories, Inc.), and approval labels are exceptions to this requirement.
6. Warning Signs: Provide warning signs where there is hazardous exposure associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.
7. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical system, provide tags of plasticized card stock, either preprinted or hand printed. Tags shall convey the message, example: “DO NOT OPEN THIS SWITCH WHEN BURNER IS OPERATING.”

PART 3 - EXECUTION
3.01 EXCAVATING AND BACKFILLING
A. Trenching and backfilling and other earthwork operations required to install the facilities specified herein shall conform to the applicable requirements of Division 2 (95% of maximum standard density). Where trenching or excavation is required in improved areas, the backfill shall be compacted to a condition equal to that of adjacent undisturbed earth
and the surface of the area restored to the condition existing prior to trenching or excavating operations. Provide a minimum of 3” of sand underneath all conduits. The plans indicate information pertaining to surface and sub-surface obstructions; however, this information is not guaranteed. Should obstructions be encountered whether or not shown, the Contractor shall alter routing of new work, reroute existing lines, remove obstructions where permitted, or otherwise perform whatever work is necessary to satisfy the purpose of new work and leave existing surfaces and structures in a satisfactory and serviceable condition. All work shall comply with OSHA Standards.

3.02 WORKMANSHIP AND CONCEALMENT
A. The work of this Section shall be performed by workman skilled in their trade. Installation shall be consistent in completeness whether concealed or exposed. Each item of electrical work shall be concealed in walls, chases, under floors and above ceilings except:
   1. Where shown to be exposed.
   2. Where exposure is necessary to the proper function.

3.03 SLEEVES, CUTTING AND PATCHING
A. This section shall be responsible for placing sleeves for all conduit passing through walls, partitions, sound walls, beams, floors, roof, etc. Sleeves through below-grade walls shall use water-tight fitting manufactured by O-Z/Gedney.
B. All cutting and patching will be done under another Division, but this Section will be responsible for timely performance of this work and layout of holes and setting sleeves.
C. All un-used sleeves shall be sealed with 2 hour UL approved fire sealant manufactured by “3M” or approved equal.
D. Refer to 26 05 33 for additional requirements.

3.04 ELECTRICAL GEAR
A. Install all electrical equipment in accordance with the National Electrical Code and as shown on the drawings.
B. Lighting contactors, time clocks, fire alarm equipment, security equipment disconnect switches, etc. mounted in mechanical/electrical rooms shall be mounted at a working height not requiring a ladder, when wall space is available. Installation of these devices at greater elevations shall be approved by the Engineer. Contractor shall provide a coordination sketch of each mechanical/electrical room noting locations and mounting heights of all electrical devices (note bottom and top elevations) shown to be installed. Sketches shall be provided to the Engineer for review and the general contractor for coordination with other trades working in these rooms.
C. Fire retardant back boards secured to drywall studs may be used for contactors, time clocks, fire alarm equipment, security equipment, and disconnect switches 60 amp or smaller. All other wall mounted devices shall be mounted to unistrut. Unistrut shall be securely mounted to the floor and structural ceiling. Toggle bolts or anchor bolts attached to drywall is not acceptable.

3.05 CLEANING
A. Clean lighting fixtures and equipment.
B. Touch-up and refinish scratches and marred surfaces on panels, switches, starters, and transformers.

3.06 CORROSIVE AREAS
A. In areas of a corrosive nature, which include but are not limited to the following: pool equipment rooms, cooling towers and areas subject to salt air, etc., provide NEMA 4 X stainless steel or fiberglass reinforced enclosures for contactors, panel boards, controllers, starters, disconnects and materials used as supporting means (i.e. plastibond unistrut, pipe, fittings). The use of spray on coating may be acceptable in some applications.

3.07 TESTS AND INSPECTIONS
A. Tests and inspection requirements shall be coordinated with Division I.
B. Date for final acceptance test shall be sufficiently in advance of completion date of contract to permit alterations or adjustments necessary to achieve proper functioning of equipment prior to contract completion date.
C. Conduct re-tests as directed by Architect on portions of work or equipment altered or adjusted as determined to be necessary by final acceptance test. No resultant delay or consumption of time as a result of such necessary re-test beyond contract completion date shall relieve Contractor of his responsibility under contract.

D. Put circuits and equipment into service under normal conditions, collectively and separately, as may be required to determine satisfactory operation. Demonstrate equipment to operate in accordance with requirements of these specifications. Perform tests in the presence of Architect. Furnish instruments and personnel required for tests.

E. Final Inspection:
   1. At the time designated by the Architect, the entire system shall be inspected by the Architect and Engineer. The contractor or his representative shall be present at this inspection.
   2. Panelboards, switches, fixtures, etc., shall be cleaned and in operating condition.
   3. Certificates and documents required hereinbefore shall be in order and presented to the Architect prior to inspection.
   4. Panel covers, junction box covers, etc., shall be removed for visual inspection of the wire, bus bars, etc.
   5. After the inspection, any items which are noted as needing to be changed or corrected in order to comply with these specifications and the drawings shall be accomplished without delay.

F. The contractor shall provide a thermographic test using an independent testing laboratory using an infrared scanning device. This test shall include but not limited to all switchboards, distribution panelboards, panelboards, automatic transfer switches and other electrical distribution devices. This test shall be conducted to locate high temperature levels. This test shall be conducted between 3 to 8 months after occupancy, but not beyond the one year warranty period. Submit test to the architect and engineer using test reporting forms. All unacceptable conditions shall be corrected prior to the end of the warranty period.

END OF SECTION
SECTION 26 02 01

COORDINATION DRAWINGS

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The requirements of the General Conditions 013100 and Supplementary Conditions apply to all Work herein.

1.02 COORDINATION DRAWINGS

A. The Contractor shall take the lead in coordinating the Mechanical, Electrical, Plumbing, Communications, Electronic Safety/Security and Fire Protection systems within the building.

B. The Contractor shall coordinate a three-dimensional (3D) model of the building which includes the Mechanical, Electrical, Plumbing, and Fire Protection systems. The Mechanical, Electrical, Plumbing, and Fire Protection Contractors shall prepare their work and generate 3D models which will be given to the Contractor for coordination. The Contractor will be provided with the REVIT model that was used to generate the contract documents, this file may be used as the background file. The Contractor shall replace the systems drawn with the actual shop drawing models. The Contractor is not limited to using REVIT, but may use any 3-D software in generating and combining the coordination model.

C. Submitting the contract drawings as coordination drawings will not be acceptable.

D. The model shall include detailed and accurate representations of all equipment to be installed based upon the reviewed equipment submittals.

E. The Contractor shall hold a 3-D coordination meeting with all sub-contractors present to review the model and discuss coordination of the installation of the building systems.

F. Upon completion of the coordination meeting, the Contractor shall submit the 3-D model and 1/4" scale drawings for review.

G. The model shall detail major elements, components, and systems in relationship with other systems, installations, and building components. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:

1. Indicate the proposed locations of pipe, duct, equipment, and other materials. Include the following:
   a. Wall and type locations.
   b. Clearances for installing and maintaining insulation.
   c. Locations of light fixtures and sprinkler heads.
   d. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
   e. Equipment connections and support details.
   f. Exterior wall and foundation penetrations.
   g. Routing of storm and sanitary sewer piping.
   h. Fire-rated wall and floor penetrations.
   i. Sizes and location of required concrete pads and bases.
   j. Valve stem movement.
   k. Structural floor, wall and roof opening sizes and details.

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

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

4. Prepare reflected ceiling plans to coordinate and integrate installations, air distribution devices, light fixtures, communication systems components, and other ceiling-mounted items.

H. Sequence of Coordination
1. Below is hierarchy of model elements and the sequencing by which the models will be coordinated:
   a. Structural and Architectural model
   b. Miscellaneous steel
   c. Perform preliminary space allocation
   d. Identify hard constraints (locations of access panels, lights, A/V space requirements, etc.)
   e. Main and medium pressure ducts from the shaft out
   f. Main graded plumbing lines and vents
   g. Sprinkler mains and branches
   h. Cold and hot water mains and branches
   i. Lighting fixtures and plumbing fixtures
   j. Smaller sized ducts and flex ducts
   k. Smaller size cold water and hot water piping, flex ducts, etc.

I. The Contractor shall not install any item until the coordination has been completed and reviewed by the Construction Manager, Owner, and A/E team.

J. This Contractor shall be responsible for coordination of all items that will affect the installation of the work of this Division. This coordination shall include, but not be limited to: voltage, ampacity, capacity, electrical and piping connections, space requirements, sequence of construction, building requirements and special conditions.

K. By submitting shop drawings on the project, this Contractor is indicating that all necessary coordination has been completed and that the systems, products and equipment submitted can be installed in the building and will operate as specified and intended, in full coordination with all other Contractors and Subcontractors.

END OF SECTION
SECTION 26 03 00

DEMOLITION WORK

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

A. The drawings do not show all demolition work required. The contractor shall make himself familiar with the required scope of work to accomplish the work required by these documents. All demolition work implied or required shall be included in the scope of this contract.

PART 2 - PRODUCTS - NOT USED

PART 3 - EXECUTION

3.01 DEMOLITION WORK

A. The contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing such loss or damage. The contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all electrical services for the new and existing facilities. The contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.

B. The contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.

C. Where existing construction is removed to provide working and extension access to existing utilities, contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.

D. Where partitions, walls, floors, or ceilings of existing construction are being removed, all contractors shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction.

E. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The contractor shall allow the Owner 2 weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.

F. 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. 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 the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

G. All items which are to be relocated shall be carefully removed in reverse to original assembly or placement and protected until relocated. The contractor shall clean and repair and provide all new materials, fittings, and appurtenances required to complete the relocations and to restore 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.

H. When items scheduled for relocation are found to be in damaged condition before work has been started on dismantling, the contractor shall call the attention of the Owner 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, at no additional cost to the Owner.
I. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring 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 Owner. 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 which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

J. During the construction and remodeling, portions of the project shall remain in service. Construction equipment, materials, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building.

K. Certain work during the demolition phase of construction may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner's Representative at least 72 hours in advance.

L. Make every effort to minimize damage to the existing building and the Owner's property. Repair, patch, or replace as required any damage which might occur as a result of work at the site. Care shall be taken to minimize interference with the Owner's activities during construction. Cooperate with the Owner and other trades in scheduling and performance of the work.

M. Include in the contract price all rerouting of existing conduits, wiring, outlet boxes, fixtures, etc., and the reconnecting of existing fixtures as necessitated by field conditions to allow the installation of the new systems. Furnish all temporary conduit, wiring, boxes, etc., as required to maintain lighting and power service for the existing areas with a minimum of interruption. Remove wire and conduit back to nearest accessible active junction box and extend to existing homeruns as required.

N. All existing lighting fixtures, switches, outlets, speakers, materials, equipment and appurtenances not included in the remodel or alteration areas are to remain in place and shall remain in service.

O. Electrical equipment, outlets, speakers, circuits to mechanical and building systems equipment, etc., which are to remain but which are served by conduit and/or circuiting that is disturbed by the remodeling work, shall be reconnected in such as manner as to leave it in proper operating condition.

P. Existing branch circuit wiring which is to be removed, shall be pulled from the raceways and the empty conduit shall be removed to a point of permanent concealment.

Q. Existing lighting fixtures shown to be removed and indicated to be reused, shall be cleaned, repaired, relamped and provided with such new accessories as may be needed for the proper installation in their new locations.

R. New circuiting indicated to be connected to existing panels shall be connected to "spares" and/or "released" breakers as applicable, or new breakers provided where space is available. Contractor shall verify the existing panel load and feeder capacity prior to adding any additional loads.

S. Within the remodeled or alteration areas where existing ceilings are being removed and new ceiling are installed, all existing lighting fixtures, other ceiling mounted devices and their appurtenances shall be removed and reinstalled into the new ceiling, unless otherwise shown or specified.

T. Within the remodeled or alteration areas where existing walls are being removed, all existing lighting fixtures, switches, receptacles, other materials and equipment and their appurtenances shall be removed, where required by the remodel work either shown or specified.

U. Refer to Architectural "Demolition" and "Alteration" plans for actual location of walls, ceilings, etc. being removed and/or remodeled.

END OF SECTION
SECTION 26 03 13

ELECTRICAL DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.01 SECTION INCLUDES
   A. Electrical demolition.
   B. The contractor shall be responsible for loss or damage to the existing facilities caused by him and his workmen, and shall be responsible for repairing such loss or damage. The contractor shall send proper notices, make necessary arrangements, and perform other services required for the care, protection and in-service maintenance of all electrical services for the new and existing facilities. The contractor shall erect temporary barricades, with necessary safety devices, as required to protect personnel from injury, removing all such temporary protection upon completion of the work.
   C. Outages of services as required by the new installation will be permitted but only at a time approved by the Owner. The contractor shall allow the Owner 2 weeks in order to schedule required outages. The time allowed for outages will not be during normal working hours unless otherwise approved by the Owner. All costs of outages, including overtime charges, shall be included in the contract amount.
   D. The contractor shall provide temporary or new services to all existing facilities as required to maintain their proper operation when normal services are disrupted as a result of the work being accomplished under this project.

1.02 RELATED SECTIONS
   A. Section 01120 - Alteration Project Procedures.
   B. Section 02072 - Minor Demolition for Remodeling.

PART 2 - PRODUCTS

2.01 MATERIALS AND EQUIPMENT
   A. Materials and equipment for patching and extending work: As specified in individual Sections.
   B. Include in the contract price all rerouting of existing conduits, wiring, outlet boxes, fixtures, etc., and the reconnecting of existing fixtures as necessitated by field conditions to allow the installation of the new systems. Furnish all temporary conduit, wiring, boxes, etc., as required to maintain lighting and power service for the existing areas with a minimum of interruption. Remove wire and conduit back to nearest accessible active junction box and extend to existing homeruns as required.

PART 3 - EXECUTION

3.01 EXAMINATION
   A. Verify field measurements and circuiting arrangements are as shown on Drawings.
   B. Verify that abandoned wiring and equipment serve only abandoned facilities.
   C. Demolition Drawings are based on casual field observation and existing record documents. Report discrepancies to Owner before disturbing existing installation.
   D. Beginning of demolition means installer accepts existing conditions.

3.02 PREPARATION
   A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
   B. Coordinate utility service outages with Utility Company.
   C. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits use personnel experienced in such operations.
   D. Existing Electrical Service: 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 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.
E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner and local fire service at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

F. Existing Telephone System: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Notify Owner and Telephone Utility Company at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

G. Existing Public Address System: 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 the Owner and at least 24 hours before partially or completely disabling system. Minimize outage duration. Make temporary connections to maintain service in areas adjacent to work area.

3.03 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of Section 01120, Section 02072, and this Section.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned wiring to source of supply.

D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes. Cut conduit flush with walls and floors, and patch surfaces.

E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets, which are not removed.

F. Disconnect and remove abandoned panelboards and distribution equipment.

G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

H. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.

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

J. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

L. Where existing construction is removed to provide working and extension access to existing utilities, contractor shall remove doors, piping, conduit, outlet boxes, wiring, light fixtures, air conditioning ductwork and equipment, etc., to provide this access and shall reinstall same upon completion of work in the areas affected.

M. Where partitions, walls, floors, or ceilings of existing construction are being removed, all contractors shall remove and reinstall in locations approved by the Architect all devices required for the operation of the various systems installed in the existing construction.

N. During the construction and remodeling, portions of the project shall remain in service. Construction equipment, materials, tools, extension cords, etc., shall be arranged so as to present minimum hazard or interruption to the occupants of the building.

O. Certain work during the demolition phase of construction may require overtime or nighttime shifts or temporary evacuation of the occupants. Coordinate and schedule all proposed down time with the Owner’s Representative at least 72 hours in advance.

P. All existing lighting fixtures, switches, outlets, speakers, materials, equipment and appurtenances not included in the remodel or alteration areas are to remain in place and shall remain in service.

Q. Electrical equipment, outlets, speakers, circuits to mechanical and building systems equipment, etc., which are to remain but which are served by conduit and/or circuiting that is disturbed by the remodeling work, shall be reconnected in such as manner as to leave it...
in proper operating condition.

R. Existing branch circuit wiring which is to be removed, shall be pulled from the raceways and the empty conduit shall be removed to a point of permanent concealment.

S. Within the remodeled or alteration areas where existing walls are being removed, all existing lighting fixtures, switches, receptacles, other materials and equipment and their appurtenances shall be removed, where required by the remodel work either shown or specified.

T. New circuiting indicated to be connected to existing panels shall be connected to "spares" and/or "released" breakers as applicable, or new breakers provided where space is available. Contractor shall verify the existing panel load and feeder capacity prior to adding any additional loads.

U. In all the remodeled areas where existing ceilings are being removed and reinstalled, all existing lighting fixtures, other ceiling mounted devices (i.e. smoked detectors, speakers, etc.) and their appurtenances shall be removed and reinstalled, unless otherwise shown or specified. This also applies to new ceiling installations.

V. Existing lighting fixtures shown to be removed and indicated to be reused, shall be cleaned, repaired, and provided with new accessories as required for the proper operation in their new locations. Provide new lamps and ballast as required.

3.04 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised circuiting arrangement.

3.05 INSTALLATION

A. Install relocated materials and equipment under the provisions of Section 01120.

3.06 REMOVAL OF MATERIALS

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 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. 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 the approval of the Owner, substitute new materials and/or items of like design and quality in lieu of materials and/or items to be relocated.

B. All items which are 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 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 are found to be in damaged condition before work has been started on dismantling, the contractor shall call the attention of the Owner 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, at no additional cost to the Owner.

D. Service lines and wiring to items to be removed, salvaged, or relocated shall be removed to points indicated on the drawings, specified, or acceptable to the Owner. Service lines and wiring 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 Owner. 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 which must remain in operation during the construction period shall not be interrupted without prior specific approval of the Owner as hereinbefore specified.

END OF SECTION
SECTION 26 05 19

WIRE, CABLE AND RELATED MATERIALS

PART 1 - GENERAL

1.01 SCOPE

A. Provide 600 volt building wire, cable and connectors and 300 volt wire, cable and connectors.

B. WORK INCLUDED: Include the following Work in addition to items normally part of this Section.
   1. Wiring for lighting and power.
   2. Automatic Control Wiring.
   3. Connection of equipment shown.
   5. Voice Communications and Sound System.

C. WORK SPECIFIED ELSEWHERE:
   1. Heating, ventilating, and air conditioning equipment.
   2. Structured cabling system.
   3. Coaxial cables

1.02 REFERENCE STANDARDS

A. UL83
B. ASTM B-3
C. All wire cable and connectors shall be UL approved.

1.03 ACCEPTABLE MANUFACTURERS

A. 600 VOLT WIRE AND CABLE
   1. Southwire
   2. Encore
   3. Cerro

B. 300 VOLT WIRE AND CABLE
   1. Westpenn
   2. Belden
   3. Alpha
   4. Tappan - Southwire

C. FLEXIBLE CABLE SYSTEMS
   1. AFC Modular Cable Systems

D. CONNECTORS
   1. Ilsco
   2. Cooper
   3. AMP - TYCO
   4. Burndy
   5. Ideal
   6. 3M
   7. Z Gedney
   8. Thomas & Betts
   9. Buchanan

1.04 SUBMITTALS

A. Shop drawings shall include, but not limited to:
   1. Cutsheets of wire, cable and connectors to indicate the performance, fabrication procedures, product variations, and accessories.

1.05 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH:

A. National Electrical Code.
B. Local, municipal, or state codes that have jurisdiction.
PART 2 - PRODUCTS

2.01 WIRING

A. All wire shall be new and continuous without weld, splice, or joints throughout its length. It must be uniform in cross-section, free from flaws, scales and other imperfections.

B. WIRE MATERIAL: Conductors shall be soft drawn, annealed copper. Aluminum wiring is not acceptable unless otherwise noted on drawings.

C. TYPES:
   1. Provide type “THHN/THWN-2” insulation for all buried feeders and service entrance conductors.
   2. Provide type “THHN/THWN-2” insulation for all branch circuits and above grade feeders.
   3. All wire No. 8 and larger shall be stranded. All wire No. 10 and smaller shall be stranded or solid.
   4. Provide type “XHHW” or other 90 degrees insulation wiring for branch circuit wiring installed through continuous rows of fixture bodies.
   5. All 300-volt cable including but not limited to telephone, fire alarm, data, CATV and security shall be UL listed for use in return air plenums.

D. CONDUCTOR SIZES
   1. Feeder conductors shall be sized for a maximum of 2% drop in rated voltage at scheduled load.
   2. Branch circuit conductors shall be sized for a maximum 3% drop in the rated voltage to the longest outlet on the circuit.
   3. Minimum wire shall be No. 12, unless otherwise shown on Drawings or required by Code.

E. COLOR CODING: No. 6 or larger shall use tape for color coding. No. 8 and smaller wire shall be color coded in accordance with the governing authority requirements or as follows:

   120/208 Volt
   Neutral: White
   Phase A: Black
   Phase B: Red
   Phase C: Blue
   Ground: Green

   277/480 Volt
   Neutral: Gray
   Phase A: Brown
   Phase B: Purple
   Phase C: Yellow
   Ground: Green

   120/240 Volt
   Neutral: White
   Phase A: Black
   Phase B: Orange
   Phase C: Blue
   Ground: Green

2.02 GROUNDING

A. Permanently connect all conduit work, motors, starters, and other electrical equipment to grounding system in accordance with the National Electrical Code.

PART 3 - EXECUTION

3.01 WIRE

A. Do not pull wire into conduit until Work of an injurious nature is completed. Where two or more circuits run to a single outlet box, each circuit shall be properly tagged. Wyreze or approved equal may be used as a lubricant where necessary.

B. Splices shall be fully made up in outlet boxes with compression crimp-on type splice connectors.
C. Joints and splices will not be permitted in service entrance or in feeders. Joints in branch circuits will be permitted where branch circuits divide, and then shall consist of one through-circuit to which the branch shall be spliced. Joints shall not be left for the fixture hanger to make. Connect joints and splices with Buchanan Series "2000" solderless connectors complete with insulating caps or properly sized twist on wire nuts. "Wago" push-in connectors are not acceptable.

D. All stranded conductors shall be furnished with lugs or connectors.

E. Connectors furnished with circuit breakers or switches shall be suitable for copper wire termination.

F. "Sta-Cons" shall be used to terminate stranded conductors on all switches and receptacles.

G. All stranded #10 and small conductors shall be terminated with an approved solderless terminal if the device or light fixture does not have provisions for clamp type securing of the conductor.

H. The jacket for all travelers used on 3-way and 4-way switches shall be pink.

I. Route conductors for 480Y/277 systems in a separate raceway. Do not combine with 208Y/120 volt or 120/240 volt systems.

J. Emergency circuits shall not be routed with normal conductors.

3.02 BALANCING SYSTEM

A. The load on each distribution and lighting panel shall be balanced to within 10% by proper arrangement of branch circuits on the different phase legs. Provide written documentation showing results. Submit with O & M manuals.

3.03 LOW VOLTAGE WIRING

A. Low voltage wiring shall be plenum rated. All wiring in mechanical rooms, electrical rooms, drywall ceiling, inaccessible areas, underground, plaster ceiling, inside concealed walls areas exposed to occupant view, and other areas subject to physical damage shall be run in conduit.

B. Low voltage wiring shall be routed in separate raceways from power wiring systems.

C. Sleeves shall be placed in the forms of concrete, masonry and fire rated walls, floor slabs and beams, for the passage of wiring. Sleeves should be set in place a sufficient time ahead of the concrete work so as not to delay the work. Sleeves shall be rigid galvanized steel.

D. Provide Caddy J-hooks supported independently from other system to support cable at 4-foot on center or closer if required by manufacture.

E. Provide a junction box to make up all joints and splices.

3.04 CABLE SUPPORTS

A. Provide cable supports in all vertical raceways in accordance with Article 300-19 of the NEC.

3.05 DEFECTS

A. Defects shall include, but are not to limited to, the following:
   1. Tripping circuit breakers under normal operation.
   2. Improperly connected equipment.
   3. Damaged, torn, or skinned insulation.

END OF SECTION
PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

1.02 SCOPE
   A. WORK COMBINED WITH OTHER SECTIONS: Combine the work specified herein with the following Sections to form a single responsibility for the Work:
      1. Electrical.
      2. Basic materials and methods.
   B. Provide electrical service, equipment and wiring device grounding as shown, scheduled and as specified.
   C. The types of grounding include, but not limited to, the grounding bonding of all equipment devices, building steel piping, and as required by the National Electrical Code, Local Inspection Department and Power Company.

1.03 STANDARDS
   A. National Electrical Code (NFPA-70)
   B. Local municipal and State codes that have jurisdiction.
   C. NECA

1.04 ACCEPTABLE MANUFACTURES
   A. Provide grounding products manufactured by Copperweld and Cadweld.

1.05 SUBMITTALS
   A. Shop drawings shall include, but not limited to the following:
      1. Cut sheets of ground rods, clamps and connectors.
      2. Grounding system diagram.

PART 2 - PRODUCTS

2.01 GENERAL
   A. Provide all materials required to construct a complete grounded electrical system.
   B. GROUND RODS: Ground rods shall be 3/4” inch diameter by 10 feet long construction with copper jacket and a steel core.
   C. CLAMPS: Ground clamps shall be copper except for steel or iron pipes in which the clamps shall be galvanized iron.
   D. CONDUCTORS: Conductors shall be connected by means of an approved pressure connector or clamp.

PART 3 - EXECUTION

3.01 INSTALLATION
   A. GENERAL: Install grounding system as shown and specified to ensure a properly grounded system.
   B. BUILDING STEEL AND PIPING SYSTEM: Install a bonding jumper between building steel and metallic piping systems to bond them to the electrical grounding system.
   C. NEUTRAL: The neutral shall be grounded only at the service entrance and other separately derived systems. The neutral shall be kept separate from the grounding system and shall not be used as a ground.
   D. GROUNDING SEPARATELY DERIVED ALTERNATING CURRENT SYSTEM
      1. TRANSFORMERS: The center point (neutral) of each wye connected transformer shall be bonded to the case and the grounding electrode conductor shall be connected to the grounded conductor (neutral).
E. GROUNDING CONDUCTOR: A grounding conductor and metallic conduit system shall bond all equipment served by the electrical system. Provide a flexible bonding jumper for isolated metallic piping and ductwork and around expansion fittings and joints.

F. CONDUIT GROUNDING BUSHING: Conduit terminating in equipment that has a ground bus such as switchboards, panelboards, etc., shall have grounding bushings installed. Ground each conduit by means of a grounding bushing and to the ground bus in the equipment.

G. MOTORS: The frame of all motors shall be grounded.

H. SPECIAL GROUNDING: Provide a #6 AWG copper grounding conductor for each telephone board, television system, etc. Terminate the grounding conductor on ground bus and to the building electrical grounding system. Refer to 800-40(d) and 820-40(d) of the NEC.

I. REMOTE PANELBOARDS: Provide a grounding electrode conductor all remote panels as required by the NEC and shown on drawings.

J. LIGHTING FIXTURES: Flexible fixture whips containing a green grounding conductor shall be used to connect light fixtures. Flexible fixture whips shall not exceed ten feet.

K. RECEPTACLES: All receptacles shall be grounded using the branch circuit grounding conductor. Receptacles shall use an approved grounding yoke.

3.02 TESTING

A. Perform a ground resistance test using a biddle analog or digital portable earth/ground resistance tester. The system resistance shall not exceed 5 Ohms. Provide additional electrodes as required (refer to 250-84 and 250-56 of the most current edition NEC). Test shall not be conducted following wet weather. Provide personal instruments to conduct these tests and submit certified test for review. Test shall be verified by Engineer.

END OF SECTION
SECTION 26 05 33

RACEWAYS

PART 1 - GENERAL

1.01 SCOPE

A. Provide electrical raceways and fittings as shown, scheduled and specified.

B. The types of raceways and fittings required are as follows:
   1. Rigid hot-dipped galvanized steel conduit (GRC) (RMC)
   2. Intermediate hot-dipped galvanized steel conduit (IMC)
   3. Electrical metallic tubing (EMT)
   4. PVC (Sch. 40 & 80)
   5. Flexible metal conduit (FMC)
   6. Liquid-tight flexible metal conduit (LFMC)
   7. PVC coated rigid galvanized steel conduit
   8. Rigid Aluminum Conduit (RAC)

1.02 STANDARDS

A. ANSI, C80.1 & C80.3
B. NEMA FB-1
C. NEMA TC3
D. UL, 6, 797 & 1242

1.03 ACCEPTABLE MANUFACTURERS

A. Raceways
   1. Allied
   2. Republic
   3. Prime Conduit (Carlon)
   4. Wheatland Tube
   5. Cantex
   6. Western Tube
   7. Robroy Industries

B. Fittings
   1. Appleton
   2. Crouse Hinds
   3. Steel City
   4. Z Gedney
   5. Carlon
   6. Raco, Inc.
   7. Bridgeport

C. Boxes
   1. RACO
   2. Thomas and Betts
   3. EATON
   4. Crouse-Hinds
   5. Appleton

D. Surface
   1. Hubbell
   2. Wiremold

1.04 SUBMITTALS

A. Product data shall include but not be limited to:
   1. Cutsheets for raceways, fitting, solvents, primers, etc.

1.05 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH:

A. National Electrical Code.
B. Local, municipal, or state codes that have jurisdiction.
PART 2 – PRODUCTS

2.01 CONDUIT AND FITTINGS

A. Rigid Galvanized Steel Conduit.
   1. Hot-dip galvanized rigid steel conduit, galvanized after fabrication. Products shall comply with UL6 and ANSI C80.1. All threads shall be galvanized after cutting. A uniform zinc coating shall be applied to the inner and outer walls.
   2. Fittings shall be threaded and shipped with thread protectors.

B. Aluminum Rigid Conduit
   1. Rigid aluminum (alloy 6063-T1) conduit shall be manufactured using 606 3 Alloy in temper designation T-1. Products shall comply with UL6A and ANSI 680.5
   2. Fittings for rigid aluminum conduit shall be threaded aluminum shipped with thread protectors.

C. PVC Coated Rigid Galvanized Steel Conduit.
   1. Conduit shall be same as rigid metal conduit with a factory-applied 40-mil-thick covering of polyvinyl chloride (PVC) bonded to the metal.
   2. Fittings shall be the same as rigid metal conduit fittings with a factory-applied, 40-mil-thick covering of polyvinyl chloride (PVC) bonded to the metal

D. Intermediate Metal Conduit (IMC).
   1. Conduit shall be similar to rigid steel conduit except thinner wall.
   2. Fittings shall be threaded hot-dipped galvanized and shipped with thread protectors.

E. Electrical Metallic Tubing (EMT).
   1. EMT shall be made of hot-dip galvanized strip steel. The interior shall be coated with a corrosion-resistant lubricant for ease of wiring pulling.

F. Rigid Nonmetallic Conduit (PVC).
   1. Conduit shall be schedule 40 or 80 polyvinyl chloride (PVC), UV stabilized, rated for 90°C conductors.
   2. Fittings shall be solvent weld socket type.

G. Flexible Metal Conduit (Greenfield).
   1. Spirally wound continuously interlocked zinc coated strip steel.
   2. Fittings shall be one screw for smaller than 1-1/2-inch, two screw for 1-1/2-inch and larger, double clamp steel or malleable iron, either cadmium plated or hot-dip galvanized.

H. Liquid-Tight Flexible Steel Conduit (Seal Tite).
   1. Spirally wound continuously interlocked zinc coated strip steel with a UV stabilized polyvinyl chloride (PVC) outer jacket bonded to the conduit.
   2. Fittings shall be compression type, malleable iron, with insulated throat, either cadmium plated or hot-dip galvanized.

2.02 PULL BOXES

A. Exterior in-ground pull boxes shall be concrete or polymer as manufactured by Brooks, Dalworth, Hubbell Quazite, or approved equivalent. Covers shall include identification of systems contained.

2.03 WIREWAYS

A. Wireways shall be made of not less than 16-gauge sheet steel for 4 inch and 6 inch square sizes and 14 gauge steel for 8 inch and 12 inch square sizes. Couplings end plates, and knockouts shall be furnished as required. Each section of wireways shall be rigidly supported.

B. The finish shall be ANSI-49 gray epoxy paint applied by a cathodic electrode position paint process over a corrosion resistant phosphate preparation for NEMA 1 wireways. Provide galvanized steel for NEMA 3R wireways. NEMA 3R wireways and auxiliary gutters are for horizontal mounting only.

2.04 FITTINGS

A. Couplings for rigid steel or intermediate conduit shall be hot dipped galvanized steel. Set screw type is not acceptable.
B. Steel or malleable iron fittings shall be used on all other raceway types except for PVC. Die-cast fittings are not allowed.

C. Couplings for aluminum raceways shall be threaded aluminum.

D. EMT systems shall utilize steel insulated throat, threadless, water tight compression type connectors and threadless steel water tight compression type couplings.

E. Coupling and connectors accessories and fittings for PVC coated rigid galvanized steel shall be PVC coated.

F. Liquidtight Flexible Metal Conduit (LFMC) fittings shall be steel. Plastic is not acceptable.

G. Provide nylon bushing on end of all low voltage cabling system conduits (sleeves, rough-ins, etc.).

PART 3 - EXECUTION

3.01 PROVIDE CONDUIT AS FOLLOWS:

A. GENERAL: The Drawings are diagrammatic, and are intended to show the general location of outlets, devices, fixtures, and arrangement and control of circuits. The Contractor shall determine exact locations by actual measurement of the building or by reference to the Architectural Drawings.

B. Except as noted or otherwise specified, all wiring shall be installed in galvanized rigid steel, rigid aluminum conduit or electrical steel tube (EMT) of the proper size to contain the number of conductors required in accordance with the latest edition of the N.E.C. Where conduit sizes are shown on the drawings, these shall take preference. Contractor shall epoxy coat galvanized rigid steel conduit for use in natatoriums.

C. Raceways shall not be routed below or within slab-on-grade, foundations, or below grade of suspended slab structures, unless specifically noted or indicated otherwise on plan.

D. EMT in sizes up to 4 inches when concealed or not exposed to damage and located indoors only. (EMT is not acceptable in wet and damp location.)

E. PVC coated rigid galvanized steel shall be used for all penetrations of slab on grade.

F. Rigid galvanized steel where embedded in concrete or masonry construction, mechanical yard or in exterior/interior applications where subject to damage.

G. Rigid aluminum shall be used in exterior applications. (i.e. roof, top of canopies)

H. PVC schedule 40 and 80 may be utilized underground, in or below slab where shown on the construction documents.

I. MINIMUM SIZE: 3/4 inch.

J. PVC coated rigid galvanized steel conduit shall be coated inside and outside.

K. PVC coated rigid galvanized steel conduit shall be used at cooling towers, corrosive areas and pool pump rooms.

L. Fixture whips: Refer to 26 51 00 for additional information.

M. Flexible metal shall be used for connecting rotating equipment installed in conditioned spaces.

N. Liquidtight Flexible Metal Conduit (LFMC) shall be used for connecting rotating equipment installed in non-conditioned spaces and outside.

O. Of such size, and so installed that conductors may be drawn in without injury or excessive strain.

P. Where entering panels, pull boxes, junction boxes, or outlet boxes, shall be secured in place with lock nuts inside and outside, and insulated bushings inside.

Q. Have Red seal type VCC or approved equal cable supports in risers, as required by N.E.C.

R. Have ends reamed after cutting and application of die.

S. Keep conduit corked and dry during construction, and swab out before conductors are pulled.

T. Have bends and offsets made with approved tools. Bends or offsets in which the pipe is crushed or deformed shall not be installed.
U. Where not embedded in concrete or masonry, be firmly secured by approved clamps, half-straps or hangers.

V. Have O.Z. Gedney or approved equal expansion fittings where crossing building expansion joints.

W. Except in the mechanical equipment rooms, run conduit concealed, and by the shortest practicable route between outlets. Install risers, drops, and offsets necessary to avoid conflict with ductwork, piping, structural members, and similar items.

X. Install exposed conduit in mechanical rooms, and elsewhere as indicated, parallel to horizontal and vertical lines of walls, ceilings, and floors.

Y. Fixtures in finished areas having suspended acoustical ceilings shall be connected to outlet boxes of lighting grid by flexible metal conduit; length not to exceed ten feet (six feet if using 3/8” manufactured fixture “whips”).

Z. Outlet boxes in partitions shall never be set back to back. They shall be offset to prevent undue noise transmission from room to room.

AA. Concealed conduit shall run in as direct manner as possible using long bends. Exposed conduit shall be run parallel with or at right angles to the lines of the building; and all bends shall be made with standard conduit elbows or conduit benders. Not more than equivalent of four quarter bends shall be used in any run between terminals and cabinet, of between outlet or junction boxes. Approved conduits shall be used in lieu of conduit elbows where ease of installation and appearance warrants their use and approved by the engineer. Conduit joints shall be made with approved couplings and unions.

BB. Conduits shall be continuous from outlet to outlet and from outlets to cabinets, junction or pull boxes and shall be electrically continuous throughout. Terminals of all conduits shall be provided with double lock nuts and bushing or terminated on conduit hubs. Use of running threads is prohibited.

CC. Each entire conduit system shall be installed complete before any conductors are drawn in. Every run of conduit shall be finished before covering up to guard against obstructions and omissions.

DD. Sleeves shall be placed in the forms of concrete, masonry and fire rated walls, floor slabs and beams, for the passage of conduits. Sleeves should be set in place a sufficient time ahead of the concrete work so as not to delay the work. Sleeves shall be rigid galvanized steel with a minimum thickness of 1.07MM and set to extend 4" above slab.

EE. All pipe penetrations through walls and concrete floors shall be fire rated by applying USG Thermafiber in the space between the concrete and the pipe. The fire rating shall be additionally sealed by using 3M brand model CP 25 or 303 fire barrier caulk and putty. All fire rating material shall be installed in accordance with manufacturer’s printed instructions.

FF. All conduit shall be cleaned and swabbed to remove all foreign matter and moisture prior to pulling wire and cable. All boxes in which conduits terminate shall be cleaned of all concrete mortar and other foreign matter.

GG. Provide #30 nylon pulling line in all conduits in which permanent wiring is not installed.

HH. All conduit shall be securely fastened and supported using hot galvanized malleable iron one-hole pipe straps, clamps, hanger or other means approved by the engineer. Supports shall be as required per NEC. Tie wire shall not be used as support or securing means. Support conduit independently of ceiling hanger wire. Use all thread rods to support outlet boxes, junction boxes and conduit.

II. When PVC conduit is routed underground, all stub-up’s and bends 15° and greater shall be PVC coated rigid galvanized steel. Use PVC coated rigid galvanized steel when penetrating concrete on grade.

JJ. Flexible and liquid-tight flexible steel conduit shall be used for final connections to utilization equipment. Liquid-tight flexible steel conduit shall be used for all exterior locations and all interior locations subject to moisture, vibrations, rotating equipment and dry-type transformers. Refer to Section 26 02 00 for additional information concerning flexible steel conduit. LFNC may be used in lieu of flexible steel conduit where allowed by the NEC and the City of San Antonio.
KK. Contact the Architect and Engineer for an installation review before covering any below grade or above grade conduit.

LL. All new outlets shall be flush mounted. In remodeled areas where wall construction prohibits flush mounting, provide Hubbell 2400 series, unless noted otherwise. Verify exact location and routing with architect before installation.

MM. Contractor shall not penetrate water proof barriers without using proper fitting to maintain barriers. This shall include exterior walls and slabs. Coordinate with Architect for proper methods.

3.02 CONDUIT CORROSION PROTECTION
A. Branch circuit conduits installed in concrete slabs on fill or grade shall be positioned in a manner to ensure complete concrete cover. In no case shall such conduits be exposed below or above the slab surfaces, or penetrate the waterproof membrane.

B. At locations where metallic conduits pass through slabs on grade or transitions below grade, PVC coated rigid galvanized conduit shall be used. Contractor may use 3M corrosive protective tape on rigid galvanized conduit in lieu of PVC coated rigid galvanized conduit.

C. Conduit installed in the air gap between the water-resistant barrier and finish brick shall not exceed 2-ft. in length.

3.03 EXPANSION JOINTS
A. Install approved expansion fitting in all conduit runs in excess of 150 feet or when crossing building expansion joints.

3.04 OUTLET AND JUNCTION BOXES
A. Provide an approved galvanized outlet box with adequate volume for number of conductors installed.

B. Provide standard galvanized switch boxes of the required number of gangs. Switch boxes where conduit is exposed shall be handy boxes or approved equal.

C. Outlet boxes for receptacles shall be similar to Universal 52151 with suitable raised cover. Receptacle boxes where conduit is exposed shall be handy boxes or approved equal.

D. Weatherproof boxes shall be FS or FD. Provide these boxes in all non-conditioned areas, exterior areas and natatoriums.

E. Outdoor boxes shall be NEMA 3R, with conduit connections made by Myers Hubs.

F. See notes and details on Drawings for special box requirements.

G. Provide junction boxes required to facilitate installation of the various conduit systems. Provide support boxes required for risers, each complete with approved cable supports as described elsewhere in this Division.

H. Outlet boxes for drywall shall be standard galvanized 4" square boxes with the appropriate device cover. Secure all outlet boxes with a backing brace connected to two adjacent studs. Mounting brackets with a single ear to rest against the backing sheet rock are not acceptable.

I. Provide floor outlet fittings for telephone to match fittings for duplex floor receptacles.

J. Provide 3-1/2" deep gangable masonry boxes in all masonry wall (CMU). Steel City GW-135-G or approved equal.

K. Provide shallow 4"x4" boxes in all demountable partitions.

L. Metallic boxes located in fire rated walls or partitions shall be separated by a minimum horizontal distance of 24 in. This minimum separation distance between metallic boxes may be reduced when “Wall Opening Protective Materials” (CLIV) are installed according to the requirements of their Classification. Metallic boxes shall not be installed on opposite side of walls or partitions of staggered stud construction unless “Wall Opening Protective Materials” are installed with the metallic boxes in accordance with Classification requirements for the protective materials.

M. Junction, pull boxes, condulets, gutters, disconnects, contactors, etc., above 2-foot x 2-foot grid ceilings shall be mounted within 18-inches of ceiling grid. Above 2-foot x 4 – foot grid ceiling they shall be mounted within 30-inches of ceiling grid. All junction box, pull box,
gutter openings shall be side or bottom accessible.

N. Junction boxes are prohibited above drywall or plaster ceilings except for lighting; and those must be mounted directly over light fixture opening. Route power, PA, fire alarm conduits to nearest lay-in ceiling.

3.05 THRU-WALL SEALS
A. Provide O.Z. Gedney “Thru-wall” seals for all conduits passing through concrete structure below grade, above grade, and floor penetrations below grade. These prevent moisture from entering the building.
B. Straight sleeves are not acceptable.

3.06 PULL BOXES
A. Interior Pull boxes shall be provided for conduit systems as required and shall be constructed of galvanized steel of not less than gauge and size specified by National Electrical Code. Size pull boxes per NEC 314.28.
B. Where two or more feeders pass through a common pull box, they shall be tagged to indicate clearly their electrical characteristics, circuit number, and panel designation.
C. Exterior in-ground pull boxes shall have open bottoms with sand and rock beds below box for drainage of water. Provide closed bottom boxes where specified. Closed bottom boxes shall be provided with sumps for portable pump to allow for extracting water. Refer to details on the drawings.
D. Pull boxes mounted in pole bases shall be coordinated with the pour of the pole base and shall be flush with finished footing.

3.07 WIREWAYS
A. Wireways shall be installed as indicated or required and locations shall be coordinated with architect.
B. Wiring in wireways shall be neatly bundled, tied and suitably tagged.

3.08 UNDERGROUND DUCTBANK SYSTEM
A. DUCT SYSTEM

END OF SECTION
SECTION 26 05 73

SHORT CIRCUIT COORDINATION STUDY ARC FLASH HAZARD ANALYSIS

PART 1 - GENERAL

1.01 SCOPE

A. The Contractor shall furnish short-circuit and protective device coordination studies as prepared by the equipment manufacturer.

B. The Contractor shall furnish short-circuit and protective device coordination studies for the electrical power system, including all existing and newly installed electrical equipment. The analysis and study shall include all distribution branches, and begin at the main building disconnect switch, or main 12KV feeder breaker, whichever is the higher main disconnect device for the structure to be studied.

C. Provide a complete short circuit study, equipment interrupting or withstand evaluation, and protective device coordination study for the power distribution system. Normal operating method, alternate operation, and operations which could result in maximum fault conditions shall be thoroughly addressed in the study. The study shall assume all motors operating at rated voltage and speed. Electrical equipment bus impedance shall be assumed as zero. Short circuit momentary duties and interrupting duties shall be calculated on the basis of maximum available fault current at the switchboard busses and motor control centers (where installed).

D. A protective device coordination study shall be performed to determine appropriate relay settings. The study shall include all distribution switchboards, motor control centers (where installed), and panel board main circuit breakers. Panel board branch circuit devices need not be considered. The phase over current and ground fault protection shall be included as well as setting for all other adjustable protective devices.

E. An equipment evaluation study shall be performed to determine the adequacy of circuit breakers, controllers, surge arresters, busways, switches, and fuses by tabulating and comparing the short circuit ratings of these devices with the available fault currents.

F. Any problem areas or inadequacies shall be promptly brought to the ENGINEERS attention.

G. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

1.02 REFERENCES

A. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
   1. IEEE 141 – Recommended Practice for Electric Power Distribution and Coordination of Industrial and Commercial Power Systems
   2. IEEE 242 – Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
   3. IEEE 399 – Recommended Practice for Industrial and Commercial Power System Analysis
   6. IEEE 1584 - Guide for Performing Arc-Flash Hazard Calculations

B. American National Standards Institute (ANSI):
   1. ANSI C57.12.00 – Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
   2. ANSI C37.13 – Standard for Low Voltage AC Power Circuit Breakers Used in Enclosures
   3. ANSI C37.010 – Standard Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

C. The National Fire Protection Association (NFPA)
1. NFPA 70 - National Electrical Code, latest edition
2. NFPA 70E – Standard for Electrical Safety in the Workplace

1.03 SUBMITTALS FOR REVIEW/APPROVAL
A. The short-circuit and protective device coordination studies shall be submitted to the design Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment drawings for manufacturing. If formal completion of the studies may cause delay in equipment manufacturing, approval from the Engineer may be obtained for preliminary submittal of sufficient study data to ensure that the selection of device and characteristics will be satisfactory.

1.04 SUBMITTALS FOR CONSTRUCTION
A. The results of the short-circuit, protective device coordination and arc flash hazard analysis studies shall be summarized in a final report. No more than five (5) bound copies of the complete final report shall be submitted. For large system studies, submittals requiring more than five (5) copies of the report will be provided without the section containing the computer printout of the short-circuit input and output data. Additional copies, where required, shall be provided on CD in PDF format.
B. The report shall include the following sections:
   1. One-line diagram
   2. Descriptions, purpose, basis and scope of the study
   3. Tabulations of circuit breaker, fuse and other protective device ratings versus calculated short circuit duties
   4. Protective device time versus current coordination curves, tabulations of relay and circuit breaker trip unit settings, fuse selection
   5. Fault current calculations including a definition of terms and guide for interpretation of the computer printout
   6. Incident energy and flash protection boundary calculations
   7. Recommendations for system improvements, where needed
   8. Executive Summary.
   9. Equipment manufacturer’s information used to prepare study
   10. Assumptions made during study.

1.05 QUALIFICATIONS
A. The short-circuit, protective device coordination and arc flash hazard analysis studies shall be conducted under the supervision and approval of a Registered Professional Electrical Engineer skilled in performing and interpreting the power system studies. The Registered Professional Electrical Engineer shall be a full-time employee of the Engineering Services Organization.

PART 2 - PRODUCT

2.01 STUDIES
A. The Contractor shall furnish short-circuit and protective device coordination studies as prepared by the equipment manufacturer.
B. The Contractor shall furnish an Arc Flash Hazard Analysis Study per NFPA 70E - Standard for Electrical Safety in the Workplace, reference Article 130.3 and Annex D.

2.02 DATA COLLECTION
A. The Contractor shall furnish all data as required by the power system studies. The Engineer performing the short-circuit, protective device coordination and arc flash hazard analysis studies shall furnish the Contractor with a listing of required data immediately after award of the contract. The Contractor shall expedite collection of the data to assure completion of the studies as required for final approval of the distribution equipment shop drawings and/or prior to the release of the equipment for manufacturing.
B. Source combination may include present and future motors and generators.
C. Load data utilized may include existing and proposed loads obtained from Contract Documents provided by Owner or Contractor.
D. Include fault contribution of existing motors in the study, with motors <100 hp grouped together. The Contractor shall obtain required existing equipment data, if necessary, to satisfy the study requirements.
2.03 SHORT-CIRCUIT AND PROTECTIVE DEVICE EVALUATION STUDY

A. Use actual conductor impedances if known. If unknown, use typical conductor impedances based on IEEE Standards 141-1993.

B. Transformer design impedances shall be used when test impedances are not available.

C. Provide the following:
   1. Calculation methods and assumptions
   2. Selected base per unit quantities
   3. One-line diagram of the system being evaluated
   4. Source impedance data, including electric utility system and motor fault contribution characteristics
   5. Typical calculations
   6. Tabulations of calculated quantities
   7. Results, conclusions, and recommendations.

D. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each:
   1. Electric utility’s supply termination point
   2. Incoming switchgear
   3. Low voltage switchgear
   4. Motor control centers
   5. Branch circuit panelboards
   6. Other significant locations throughout the system.

E. For grounded systems, provide a bolted line-to-ground fault current study for areas as defined for the three-phase bolted fault short-circuit study.

F. Protective Device Evaluation:
   1. Evaluate equipment and protective devices and compare to short circuit ratings
   2. Adequacy of switchgear, motor control centers, and panelboard bus bars to withstand short-circuit stresses
   3. Adequacy of transformer windings to withstand short-circuit stresses
   4. Cable and busway sizes for ability to withstand short-circuit heating
   5. Notify Owner in writing of any new or existing circuit protective devices improperly rated for the calculated available fault current.

2.04 PROTECTIVE DEVICE COORDINATION STUDY

A. Proposed protective device coordination time-current curves shall be graphically displayed on log-log scale paper.

B. Include on each curve sheet a complete title and one-line diagram with legend identifying the specific portion of the system covered.

C. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which device is exposed.

D. Identify device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.

E. Plot the following characteristics on the curve sheets, where applicable for this project:
   1. Electric utility’s protective device
   2. Medium and low voltage fuses including manufacturer’s minimum melt, total clearing, tolerance, and damage bands
   3. Low voltage equipment circuit breaker trip devices, including manufacturer’s tolerance bands
   4. Transformer full-load current, magnetizing inrush current, and ANSI transformer withstand parameters
   5. Conductor damage curves
   6. Ground fault protective devices, as applicable
   7. Pertinent motor starting characteristics and motor damage points
   8. Other system load protective devices for the largest branch circuit and the largest feeder circuit breaker in each motor control center.

F. Provide adequate time margins between device characteristics such that selective operation is provided, while providing proper protection.
2.05 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E-2004, Annex D.

B. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Alternative methods shall be presented in the proposal.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, motor-control centers, panelboards, busway and splitters) where work could be performed on energized parts.

D. The Arc-Flash Hazard Analysis shall include all significant locations in 240 volt and 208 volt systems fed from transformers equal to or greater than 75 kVA.

E. Safe working distances shall be specified for calculated fault locations based upon the calculated arc flash boundary considering an incident energy of 1.2 cal/cm².

F. The Arc Flash Hazard analysis shall include calculations for maximum and minimum contributions of fault current magnitude. The minimum calculation shall assume that the utility contribution is at a minimum and shall assume a minimum motor load. Conversely, the maximum calculation shall assume a maximum contribution from the utility and shall assume motors to be operating under full-load conditions.

G. Arc flash computation shall include both line and load side of main breaker calculations, where necessary.

H. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584-2002 section B.1.2.

2.06 REPORT SECTIONS

A. Input Data:
   1. Short-circuit reactance of rotating machines
   2. Cable and conduit materials
   3. Transformers
   4. Circuit resistance and reactive values.

B. Short-Circuit Data:
   1. Source fault impedance and generator contributions
   2. X to R ratios
   3. Asymmetry factors
   4. Motor contributions
   5. Short circuit kVA

C. Recommended Protective Device Settings:
   1. Phase and Ground Relays:
      a. Current transformer ratio
      b. Current setting
      c. Time setting
      d. Instantaneous setting
      e. Specialty non-overcurrent device settings
      f. Recommendations on improved relaying systems, if applicable

   2. Circuit Breakers:
      a. Adjustable pickups and time delays (long time, short time, ground)
      b. Adjustable time-current characteristic
      c. Adjustable instantaneous pickup
      d. Recommendations on improved trip systems, if applicable.

D. Incident energy and flash protection boundary calculations
   1. Arcing fault magnitude
   2. Device clearing time
   3. Duration of arc
   4. Arc flash boundary
5. Working distance
6. Incident energy
7. Hazard Risk Category
8. Recommendations for arc flash energy reduction

PART 3 - EXECUTION

3.01 FIELD ADJUSTMENT
A. The Contractor shall adjust relay and protective device settings according to the recommended settings table provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.
B. Make minor modifications to equipment as required to accomplish conformance with short circuit and protective device coordination studies.
C. Notify Owner in writing of any required major equipment modifications.
D. Following completion of all studies, acceptance testing and startup by the field engineering service division of the equipment manufacturer, a 2-year warranty shall be provided on all components manufactured by the engineering service parent manufacturing company.

3.02 ARC FLASH WARNING LABELS
A. The vendor shall provide a 3.5 in. x 5 in. thermal transfer type label of high adhesion polyester for each work location analyzed.
B. The label shall have an orange header with the wording, “WARNING, ARC FLASH HAZARD”, and shall include the following information:
   1. Location designation
   2. Nominal voltage
   3. Flash protection boundary
   4. Hazard risk category
   5. Incident energy
   6. Working distance
   7. Engineering report number, revision number and issue date.
C. Labels shall be machine printed, with no field markings.
D. Arc flash labels shall be provided in the following manner and all labels shall be based on recommended overcurrent device settings.
   1. For each 600, 480 and applicable 208 volt panelboards, one arc flash label shall be provided.
   2. For each motor control center, one arc flash label shall be provided.
   3. For each low voltage switchboard, one arc flash label shall be provided.
E. Labels shall be field installed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

3.03 ARC FLASH TRAINING
A. The equipment vendor shall train personnel of the potential arc flash hazards associated with working on energized equipment (minimum of 4 hours). Maintenance procedures in accordance with the requirements of NFPA 70E, Standard for Electrical Safety Requirements for Employee Workplaces, shall be provided in the equipment manuals. The training shall be certified for continuing education units (CEUs) by the International Association for Continuing Education Training (IACET).

END OF SECTION
SECTION 26 06 34
LOW VOLTAGE RACEWAY SYSTEM

PART 1 - GENERAL
1.01 GENERAL REQUIREMENTS
   A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.
1.02 WORK INCLUDED
   A. Furnish and install a complete raceway system for telephone system, consisting of cabinets, conduit, junction boxes, etc. This shall include by not limited to fire alarm, access control, structured cabling, audio-video, intercommunications, sound reinforcing, intrusion detection, telephone.
1.03 WORK SPECIFIED ELSEWHERE
   A. Section 26 02 00 - Basic Materials and Methods.
   B. Section 26 05 33 - Raceways.
   C. Section 26 05 19 - Wire, Cable and Related Materials.
1.04 WORK NOT INCLUDED
   A. Cabling
   B. Equipment
   C. Division 27
   D. Division 28

PART 2 - PRODUCTS
2.01 COMPONENTS
   A. Conduit - Refer to Section 26 05 33.
   B. Backboards - 3/4" X 4’ X 8’ fire rated plywood painted white.
   C. Outlet Boxes - Refer to Section 26 05 33.
   D. Pull and junction boxes - Refer to Section 26 05 33.
   E. Floor Boxes - Refer to Section 26 05 33.
   F. Cabinets - Consult low voltage system installer/supplier.

PART 3 - EXECUTION
3.01 INSTALLATION
   A. Refer to Section 26 05 33 for underground service entrance.
   B. Provide pull boxes in telephone conduit runs spaced not greater than 100 ft. apart, and on backboard side of runs with more than two right angle bends.
   C. Place telephone label on pull and junction boxes.
   D. Provide pull wire in each telephone run.
   E. Provide plywood backboards and duplex receptacle in the telephone equipment room. Confirm location on jobsite prior to installation.
   F. All terminal cabinets/backboards and conduit shall be sized per the recommendations of the telephone system installer.

END OF SECTION
SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract Documents, including General and Supplementary Conditions and Division 01 Specifications, apply to this section.

B. Related sections:
   1. SECTION 01 91 00 - GENERAL COMMISSIONING REQUIREMENTS

1.02 SUMMARY

A. The commissioning of the lighting system and associated controls shall be performed by an impartial technical firm hired by the owner or shall be performed by the installing contractor if the owner has not hired a commissioning firm. The commissioning provider shall be certified under one or more of the following certifications:
   1. CxA - Certified Commissioning Authority - ACG
   2. CBCP - Certified Building Commissioning Professional - AEE
   3. CCP - Certified Commissioning Professional - BCA
   4. CPMP - Certified Process Management Professional - ASHRAE
   5. BSC - Building System Commissioning Certification - NEBB

B. The commissioning provider (Commissioning authority) shall be responsible for leading the entire construction team through the commissioning process including, but not limited to, conducting the commissioning kick-off meeting, preparing the commissioning plan, preparing pre-functional checklists, preparing functional test scripts, participation in functional testing and preparation of required documentation and reports.

1.03 RESPONSIBILITIES

A. Contractor: Responsibilities of the Contractor as relate to Commissioning Process include, but are not limited to the following:
   1. Facilitate coordination of Commissioning work by Commissioning authority.
   2. Attend Commissioning meetings or other meetings called by Commissioning authority to facilitate the Commissioning Process.
   3. Review Functional Performance Test procedures for feasibility, safety, and impact on warranty, and provide Commissioning authority with written comment on same.
   4. Provide all documentation relating to manufacturer’s recommended performance testing of equipment and systems.
   5. Provide Operations & Maintenance data to Commissioning authority for preparation of checklists and training manuals.
   6. Provide As-built drawings and documentation to facilitate Testing.
   7. Assure and facilitate participation and cooperation of Sub Contractors and equipment suppliers as required for the Commissioning Process.
   8. Certify to Commissioning authority that installation work listed in Pre-Functional Checklists has been completed.
   9. Install systems and equipment in strict conformance with project specifications, manufacturer’s recommended installation procedures, and Pre-Functional Checklists.
   10. Provide data concerning performance, installation, and start-up of systems.
   11. Provide copy of manufacturers filled-out start-up forms for equipment and systems.
   12. Ensure systems have been started and fully checked for proper operation prior to arranging for Testing with Commissioning authority. Prepare and submit to Commissioning authority written certification that each piece of equipment and/or system has been started according to manufacturer’s recommended procedure, and that system has been tested for compliance with operational requirements.
      a. Contractor shall carry out manufacturer’s recommended start-up and testing procedures, regardless of whether or not they are specifically listed in Pre-Functional Checklists.
      b. Contractor is not relieved of obligation for systems/equipment demonstration where performance testing is required by specifications, but a Functional Performance Test is not specifically designated by Commissioning authority.
13. Coordinate with Commissioning authority to determine mutually acceptable date of Functional Performance Tests.
14. Provide qualified personnel to assist and participate in Commissioning.
15. Provide test instruments and communications devices, as prescribed by Commissioning authority, required for carrying out Testing of systems.
16. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment. Manufacturer shall provide the test equipment, demonstrate its use, and assist in the commissioning process. Proprietary test equipment shall become the property of the Owner upon completion of commissioning.
17. Ensure deficiencies found in the Commissioning Issues Log are corrected within the time schedule shown in the Commissioning Plan.
18. Provide Commissioning authority with all submittals, start-up instructions manuals, operating parameters, and other pertinent information related to Commissioning Process. This information shall be routed through Architect.
19. Prepare and submit to Commissioning authority proposed Training Program outline for each system.
20. Coordinate and provide training of Owner’s personnel.
21. Prepare Operation & Maintenance Manuals and As-Built drawings in accordance with specifications; submit copy to Commissioning authority in addition to other contractually required submissions. Revise and resubmit manuals in accordance with Design Professionals and Commissioning authority’s comments.
22. Commissioning requires participation of this Division Subcontractors to ensure that systems are operating in manner consistent with Contract Documents. All costs associated with the participation of Contractor, Sub-Contractors, Design Professionals, and Equipment Vendors in the Commissioning Process shall be included as part of the Construction Contract.

B. Subcontractors and vendors shall prepare and submit to Commissioning Agent proposed Startup procedures to demonstrate proper installation of systems, according to these specifications and checklists prepared by Commissioning authority.

C. Electrical contractor shall provide a letter certifying the installed lighting controls meet documented performance criteria specified in the commissioning plan within 90 days of substantial completion.

1.04 COMMISSIONING PLAN

A. Commissioning Process tasks and activities:
   1. Commissioning kick-off meeting: Conducted by commissioning authority and attended by construction team and design team.
   2. Pre-functional checklists: Prepared by the commissioning authority and filled out by subcontractors performing the work that is applicable.
   3. Site visits to review installation of applicable systems and progress of checklist documentation performed and reported by commissioning authority.
   4. Functional testing: Commissioning authority shall conduct functional testing with assistance of applicable subcontractors and document successful results as well as deficiencies (issues). Functional performance testing shall demonstrate the installation and operation of components, systems, and system-to-system interfacing in accordance with plans and specifications.
   5. Preliminary commissioning report: Commissioning authority shall issue a preliminary commissioning report to the owner that has results of the first round of functional testing including deficiencies discovered.
   6. Systems manual: Commissioning authority shall compile the systems manual using submittal data provided by the general contractor and applicable subcontractors.
   7. Final commissioning report: Commissioning authority shall issue final commissioning report documenting the entire process and final results of functional testing. Report shall include final testing and balancing report.

B. Electrical System Equipment to be tested
   1. Occupancy sensors
   2. Time switch controls
   3. Daylighting controls
   4. Electrical Service and Distribution System.
C. Testing functions and conditions
   1. Daylighting control devices
      a. Verify the devices have been calibrated, properly located and adjusted.
      b. Loads adjust to light level set points in response to daylight.
      c. Location of calibration equipment is accessible to authorized personnel only.
   2. Time switches
      a. Verify schedule, time, date and programming is accurate.
      b. Verify override time limit is set, battery is installed and switch operates the lights that are specified in the design documents.
      c. All specified lights can be turned on and off by area control switch.
      d. Manual override switch allows only the lights in the space where the switch is located turn on or remain on until next scheduled shut off.
   3. Occupant sensors:
      a. Certify the sensor has been located and aimed in accordance with manufacturer recommendations.
      b. For projects with fewer than seven sensors, each sensor shall be tested.
      c. For projects with more than seven occupant sensors, testing shall be done for each unique combination of sensor type and space geometry. Where multiples of each combination are provided not less than 10 percent shall be tested.
      d. Verify correct operation of status indicators.
      e. Controlled lights turn off or down to the permitted level with in the required time.
      f. For auto-on sensor, the lights turn on to the permitted level when an occupant enters space.
      g. Verify the lights are not incorrectly turned-on by movement in adjacent areas or by HVAC operation.

D. Performance criteria
   1. Daylighting controls shall maintain specified light levels within 5% of design.
   2. All time switches shall be accurate to time on cellular network devices.

PART 2 - PRODUCTS

2.01 NO PRODUCTS SUPPLIED

PART 3 - EXECUTION

3.01 GENERAL
   A. This Division has startup responsibilities and are required to complete sub-systems so COMPLETE SYSTEMS are fully functional. Insuring they meet design requirements of Contract Documents. Commissioning procedures and testing do not relieve or lessen this responsibility or shift this responsibility or shift this responsibility in whole or in part, to Commissioning Agent or Owner.
   B. Coordinate with other Sub-Contractors and equipment vendors to set aside adequate time to address Pre-Functional Checklists, Functional Performance Tests, Operations & Maintenance Manual creation, Owner Training, and associated coordination meetings.
   C. Commissioning authority will also conduct site inspections at critical times and issue Cx Field Reports with observations on installation deficiencies so that they may be issued by Architect as deemed appropriate.

3.02 WORK PRIOR TO COMMISSIONING
   A. Complete all phases of the work so the systems can be started, adjusted, balanced and otherwise tested.
   B. See pertinent specification sections in this Division, which outline responsibilities for start-up of equipment with obligations to complete systems, including all sub-systems so that they are fully functional.
   C. Assist Commissioning Agent with all information pertaining to actual equipment and installation as required complete the full commissioning scope.
   D. Contractor shall prepare startup procedures to demonstrate compliance with pre-functional checklists, and coordinate scheduling for completion of these checklists.
   E. A minimum of seven (7) days prior to date of system startup, submit to Commissioning Agent for review, detailed description of equipment start-up procedures which contractor
proposes to perform to demonstrate conformance of systems to specifications and Checklists.

3.03 PARTICIPATION IN COMMISSIONING
A. Attend meetings related to the Commissioning Process; arrange for attendance by personnel and vendors directly involved in the project, prior to testing of their systems.
B. Provide skilled technicians to startup and test all systems, and place systems in complete and fully functioning service in accordance with Contract Documents.
C. Provide skilled technicians, experienced and familiar with systems being commissioned, to assist Commissioning authority in commissioning process.

3.04 WORK TO RESOLVE DEFICIENCIES
A. Complete corrective work in a timely manner to allow expeditious completion of Commissioning Process. If deadlines pass without resolution of identified problems, Owner reserves the right to obtain supplementary services and/or equipment to resolve the problem. Costs thus incurred will be Contractor’s responsibility.

3.05 PRE-FUNCTIONAL CHECKLISTS (PFC)
A. Contractor shall complete Pre-Functional Checklists to validate compliance with Contract Documents installation and start-up requirements, for this Division’s systems.
B. Refer to commissioning plan for detailed list of equipment to be commissioned.

3.06 FUNCTIONAL PERFORMANCE TESTING (FPT)
A. Contractor, in cooperation with Commissioning Agent, shall conduct Functional Performance Testing to validate compliance with Contract Documents.
B. Refer to commissioning plan for detailed list of equipment to be commissioned.
C. Assist Commissioning authority in Functional Testing by removing equipment covers, opening access panels, etc. Furnish ladders, flashlights, meters, gauges, or other inspection equipment as necessary.
D. Sampling
   1. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy.
   2. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. It is noted that no sampling by Subs is allowed in pre-functional checklist execution.
   3. A common sampling strategy is the “xx% Sampling - yy% Failure Rule”, defined by the following example.
      a. xx = the percent of the group of identical equipment to be included in each sample.
      b. yy = the percent of the sample that if failing, will require another sample to be tested.
      c. The example below describes a 20% Sampling - 10% Failure Rule.
      d. Randomly test at least 20% (xx) of each group of identical equipment. In no case test less than three units in each group. This 20%, or three, constitute the “first sample.”
      e. If 10% (yy) of the units in the first sample fail the functional tests, test another 20% of the group (the second sample).
      f. If 10% of the units in the second sample fail, test all remaining units in the whole group.
      g. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.
E. Re-Testing And Failure To Remedy Deficiencies
   1. Despite Contractor’s best efforts to ensure systems are problem-free, it is expected that some deficiencies will be found during initial inspection of Pre-functional Checklist, and during initial Functional Testing; such deficiencies are expected to be minimal.
2. It is Contractor’s responsibility to remedy identified deficiencies, both in Pre-functional Checklist and in Functional Testing phases of work, in a timely and thorough manner.
3. It is Contractor’s responsibility to ensure that all deficiencies are corrected prior to requesting a re-inspection or re-test of systems and equipment. Do not request re-inspection or re-test until deficiencies are corrected.
   a. At his discretion, CxA may agree to re-testing systems or equipment where deficiencies remain which are beyond Contractor’s control to resolve expeditiously.
   b. Typically such re-testing of incomplete systems and equipment will take place only if remaining deficiencies are minor in scope and nature, and are of such nature that they cannot be resolved in a timely manner (such as those due to difficulties in obtaining parts, or where Owner has requested a change that has delayed work, etc.)
4. CxA will carry out a second re-inspection or re-test of systems and equipment subsequent to receiving Contractor’s request.
   a. If CxA finds deficiencies identified in initial inspection or test have not been remedied (with exception of un-resolvable deficiencies in 3.b. above), and such remaining deficiencies are significant enough to require additional inspection or re-testing, Contractor will be back-charged for CxA’s expenses, and time at a rate of $150.00 per hour and $100.00 expenses, for a third and any subsequent re-inspections and re-tests.

F. Deferred Testing
1. “Seasonal Commissioning” pertains to testing during peak heating or cooling seasons when HVAC equipment is operating at full-load or heavy-load conditions. Initial commissioning will be done as soon as contract work is completed, regardless of season. Seasonal Commissioning under full- or heavy-load conditions other than the current season will be handled at later time by GC and CxA.
2. If adequate load may be artificially placed upon heating or cooling equipment, CxA, at his discretion, may perform functional testing during non-peak load periods.
3. GC is to provide services of personnel and participate in seasonal testing process in the same manner as he would in non-seasonal testing.
4. Until off-season commissioning can be accomplished, Owner may retain an amount from GC’s payment sufficient to cover the cost of off-season testing.
5. Unforeseen Deferred Tests: If any check or test cannot be completed due to building structure, required occupancy condition, or other reason, execution of checklists and functional testing may be delayed upon approval of Owner. Tests shall be conducted in same manner as seasonal tests, as soon as possible. Services of required parties will be negotiated. Make final adjustments to Operation and Maintenance Manuals and record drawings due to unforeseen deferred tests.
6. GC is to provide services of personnel and participate in deferred testing in the same manner as he would for normal commissioning.

3.07 TRAINING
A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.
B. Contractor shall be responsible for training coordination and scheduling, and ultimately to ensure that training is completed.
C. The training agenda (plan) shall include, at a minimum, the following elements:
   1. Purpose of equipment.
   2. Principle of how the equipment works.
   3. Important parts and assemblies.
   4. How the equipment achieves its purpose and necessary operating conditions.
   5. Most likely failure modes, causes and corrections.
   6. On site demonstration.
D. Commissioning Agent shall be responsible for overseeing and approving content and adequacy of training of Owner personnel for all installed systems. Provide Commissioning Agent with training plan two weeks before planned training.
3.08 OPERATIONS & MAINTENANCE MANUALS
   A. The following requirements are in addition to Operations & Maintenance requirements specified elsewhere in this specifications manual.
   B. Contractor shall compile and prepare documentation for equipment and systems specified in this Division, and shall deliver documentation to Contractor for inclusion in Operation & Maintenance Manuals, in accordance with requirements of Division 01, prior to training Owner personnel.
   D. Operation and maintenance manuals shall include, service agency contact information, maintenance requirements, controls system settings and a narrative of how each system is intended to operate, including set points.

3.09 DOCUMENTATION
   A. Commissioning authority shall provide documentation of process as follows:
      1. Preliminary commissioning report including test procedures, results of testing, itemization of deficiencies, deferred tests and climatic conditions required for performance of deferred tests. Preliminary commissioning report shall be issued to owner to demonstrate the first pass of testing has occurred and to demonstrate compliance with applicable codes.
      2. Final commissioning report shall include the final test and balance report, final results of functional testing, disposition of deficiencies discovered during testing, including the details of corrective measures used and functional testing procedures used for repeatability of testing in the future.

END OF SECTION
SECTION 26 22 13

LOW VOLTAGE DISTRIBUTIONS TRANSFORMERS

PART 1 - GENERAL

1.01 SCOPE
A. Provide 480 volt primary step down transformers as shown, scheduled and as specified.
B. The type of transformers required includes dry-type general purpose transformers.

1.02 STANDARDS
A. Products shall be designed, manufactured, tested and installed in compliance with applicable ANSI/IEEE and NEMA standards.
B. All low voltage transformers shall be UL listed and labeled.
C. All low voltage transformers 15 kVA and larger shall meet or exceed post-January 1, 2016 U.S. DOE efficiency requirements Energy, 10 C.F.R. §431.196(a)(2) (2015) regardless of whether transformer date of manufacture is pre or post January 1, 2016.

1.03 ACCEPTABLE MANUFACTURERS
A. Provide one of the following manufacturers for general purpose use:
   1. General Electric Company
   2. Square D Company
   3. Power Quality International
   4. Eaton

1.04 SUBMITTALS
A. Shop drawings shall include, but not be limited to:
   1. Cutsheets of transformers with sound and load ratings, dimensions, weights, impedance rating, insulation type, temperature rise and tap configurations.

1.05 REQUIREMENTS OF REGULATORY AGENCIES
A. National Electrical Code.
B. Local, municipal, and/or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.01 GENERAL PURPOSE
A. Provide dry type, two-winding transformers with primary and secondary voltages and KVA ratings as shown on plans. Transformers shall operate at 60 hertz. All transformers shall be manufactured with standard materials and components.

2.02 MATERIALS AND COMPONENTS FOR GENERAL PURPOSE TRANSFORMERS
A. All cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability, and low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point. The core laminations shall be clamped together with structural steel angles. The completed core and coil shall be isolated from the base by means of rubber, vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure. The vibration isolating system shall be designed to provide a permanent fastening of the core and coil to the enclosure. Sound isolating system requiring the complete removal of all fastening devices will not be accepted. Windings shall be copper or electrical grade aluminum terminated on tin plated or copper bars. Foil windings are not acceptable.
B. The transformer core shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with NEMA, IEEE and ANSI standards.
C. Transformer coils shall be of continuous-wound type construction and shall be impregnated with non-hygroscopic, thermo-setting varnish.
D. Transformers shall be enclosed in drip-proof, metallic enclosures designed to provide for air cooling and prevent accidental contact with live conductors. Wiring compartment shall
be located below the core and coil and cooled by air circulation or insulated from the core and coil by means of a suitable thermal insulation barrier. Transformer exposed to weather or installed in a sprinkled area shall have rain shields on all openings. Entire transformer enclosure shall be cleaned, phosphatized, primed and painted with a gray, baked enamel.

E. Transformers shall operate at 100% nameplate KVA rating continuously while in a 40 degree C ambient without exceeding the rated average winding temperature rise of the ANSI insulation system as described below.

<table>
<thead>
<tr>
<th>RATING</th>
<th>PHASE INSULATION-TEMP. RISE</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.025 through 3 KVA</td>
<td>SingleType B - 80° C</td>
</tr>
<tr>
<td>5 through 25 KVA</td>
<td>SingleType F - 115° C</td>
</tr>
<tr>
<td>3 through 15 KVA</td>
<td>ThreeType F - 115° C</td>
</tr>
<tr>
<td>37½ KVA and larger</td>
<td>SingleType H - 150° C</td>
</tr>
<tr>
<td>30 KVA and larger</td>
<td>ThreeType H - 150° C</td>
</tr>
</tbody>
</table>

F. Transformers shall have minimum full load rated taps in the primary windings as follows:

<table>
<thead>
<tr>
<th>RATING</th>
<th>TAPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 through 25 KVA</td>
<td>2 - 5% FCBN</td>
</tr>
<tr>
<td>15 through 300 KVA</td>
<td>6 - 2-½% TAPS, 2 above and 4 below nominal</td>
</tr>
</tbody>
</table>

G. Maximum sound ratings shall be as follows:

<table>
<thead>
<tr>
<th>KVA</th>
<th>dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 9</td>
<td>40</td>
</tr>
<tr>
<td>10 to 50</td>
<td>45</td>
</tr>
<tr>
<td>51 to 150</td>
<td>50</td>
</tr>
<tr>
<td>151 to 300</td>
<td>55</td>
</tr>
<tr>
<td>301 to 500</td>
<td>60</td>
</tr>
</tbody>
</table>

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install transformer in accordance with manufacturer’s written instructions, and recognized industry practices.

B. Housekeeping Pad: Provide a nominal 3-½” high, 2500 PSI (28 Day) concrete reinforced pad with number 6 welded wire mesh. The pad shall conform to the shape of the transformer and extend at least 3 inches beyond the length and width of the transformer. All corners of the pad shall be rounded.

C. Mounting: Install floor mounted transformers on properly sized rubber-in-shear vibration isolators. Trapeze mounted transformers shall use rubber-in-shear hangers. Wall mounted transformers shall not be mounted directly to the wall without vibration isolation.

D. Connection: Route conductors in a minimum of 2 feet of flexible steel conduit to transformer enclosure. Provide grounding conductor sized per NEC, connected to the building grounding electrode system.

3.02 TESTING

A. Insulation, Tests: Prior to energization, check transformers windings for continuity and test the insulation resistance. Tests shall be made using a Biddle Megger or equivalent test instrument, per manufacturers’ recommendations. Provide written documentation of testing. Submit with O & M manuals.

B. Tap Setting: Measure current and voltage under load conditions to provide correct tap settings.

END OF SECTION
SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 SCOPE

A. Provide panelboards as shown, scheduled and as specified herein.
B. The types of panelboards include:
   1. Panelboards.
   2. Power distribution panelboards.

1.02 STANDARDS

A. Products shall be designed, manufactured, tested and installed in compliance with UL, NEMA and ANSI applicable standards.
   1. UL 50 and UL 50E - Enclosures for Electrical Equipment
   2. UL 67 - Panelboards
   3. UL 489 - Molded Case Circuit Breakers and Circuit Breaker Enclosures
   4. UL 943 - Ground fault Circuit Interrupters
   5. NEMA PB 1 - Panelboards
   6. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less
   7. NEMA, ABI, Molded Case Circuit Breakers and Molded Case Switches
   9. NEMA KSI, Enclosed and Miscellaneous Distribution Equipment Switches (600V)
   10. NFPA 70 - National Electrical Code (NEC)
   11. ANSI C12.1 - Electric Meters - Code for Electricity Metering
   12. ANSI C12.20 - American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Classes

B. Products shall conform to all applicable UL standards and shall be UL-labeled.

1.03 ACCEPTABLE MANUFACTURERS

A. Provide one of the following manufacturers:
   1. General Electric Company/ABB
   2. Square D Company
   3. Siemens
   4. Eaton

1.04 SUBMITTALS

A. Shop drawings shall include, but not be limited to:
   1. Cutsheets of all enclosures, circuit breakers, fusible switches, bussing, rating, schedules and all accessories clearly labeled.

1.05 REQUIREMENTS OF REGULATORY AGENCIES

A. WORK IN ACCORDANCE WITH:
   2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.01 MATERIALS AND COMPONENTS

A. General
   1. Provide power distribution and panelboards as indicated in the panelboard schedule and as shown on the plans. Power distribution panelboards shall be equipped with fusible switches or circuit breakers as shown on the schedule. Panelboards shall be equipped with thermal-magnetic, molded case circuit breakers of frame and trip ratings as shown on the schedule.

B. Busing Assembly and Temperature Rise
   1. Panelboard bus structure and main lugs or main breaker shall have current ratings as shown on the panelboard schedule. Such ratings shall be established by heat rise tests with maximum hot spot temperature on any connector or bus bar not to exceed
Panelboards

65°C, rise above 40°C ambient. Heat rise test shall be conducted in accordance with Underwriters Laboratories Standard UL 67. The use of conductor dimensions will not be accepted in lieu of actual heat tests. All current carrying parts of the bus shall be tin or silver plated copper.

2. Bus structure shall be isolated. Bus bar connections to the branch circuit breakers shall be distributed phase or phase sequence type and shall accept bolt-on circuit breakers for lighting and appliance panelboards.

3. The lugs for terminating conductors shall be rated at 75°C on all panel boards and circuit breakers.

4. Provide a non-insulated bare copper ground bus. Provide an isolated ground copper bus in each panel serving isolated ground circuits as indicated on panel schedule or one-line diagram. Provide a full size copper neutral bus in each panelboard enclosure. Provide a 200% neutral buss when served by a harmonic mitigating transformer and any K4 or higher rated transformers.

C. Distribution Panelboards

1. Provide arc energy reduction switch for each overcurrent device rated 1200 amps or larger to comply with 240.87 of the NEC. Switch shall be equipped with a pad lockable cover with a blue LED pilot light that illuminates when system is activated. Locate switch and cover recessed mounted adjacent to the switch it serves or remote as indicated on the plans. Provide label and all required hardware. Remote switch(es) shall be flush mounted in wall near entry to the room.

2. Circuit breakers shall be equipped with individually insulated, braced and protected connectors. The front faces of all circuit breakers shall be flush with each other. Large, permanent, individual circuit numbers shall be affixed to each breaker in a uniform position. Tripped indication shall be clearly shown by the breaker handle taking a position between “ON” and “OFF”. Provisions for additional breakers shall be such that no additional connectors will be required to add breakers. Circuit breakers shall be of the frame size, trip setting and interrupting capacity as indicated on the drawings. Circuit breakers shall be rated 65,000 AIC unless otherwise noted on plans.

3. All fusible switches shall be quick-make, quick-break with visible blades and dual horsepower ratings. Switch handles shall physically indicate “ON” and “OFF” positions. Switches shall be lockable only in the “OFF” position and accept three industrial type heavy duty padlocks. Switch covers and handles shall be interlocked to prevent opening in the “ON” position. A means shall be provided to permit authorized personnel to release the interlock for inspection purposes. Switches shall include positive pressure rejection type fuse clips for use with UL Class R fuses or Class J fuses and be UL labeled for 200,000 AIC.

D. 480/277 Volt Panelboards

1. Main breakers shall be vertically mounted. Branch mounted main breakers are not acceptable. Provide electronic trip mains with long term, short term and instantaneous trips as indicated on drawings and required for selective coordination.

2. Circuit breakers shall be bolt-on thermal-magnetic, molded case circuit breakers. Breakers shall be 1, 2 or 3 pole with an integral crossbar to assure simultaneous opening of all poles in multiple circuit breakers. Breaker shall have an over-center, trip-free, toggle-type operating mechanism with quick-make, quick-break action and positive handle indication. Handles shall have “ON”, “OFF” and “TRIPPED” positions. Circuit breakers shall be UL listed in accordance with UL Standard 489 and shall be rated 277 volt ac (single pole, 15-30 amperes) or 480Y/277 volts ac (2 and 3 pole) with continuous current ratings as noted on the plan. Interrupting ratings shall be a minimum of 18,000 rms symmetrical amperes at 277 volts ac (single pole) or 480Y/277 volts ac (2 and 3 pole) unless otherwise noted on plans.

E. 240 Volt Panelboards

1. Main breakers shall be vertically mounted. Branch mounted main breakers are not acceptable. Provide electronic trip mains with long term, short term and instantaneous trips as indicated on drawings and required for selective coordination.

2. Circuit breakers shall be bolt-on thermal-magnetic, molded case circuit breakers. Breakers shall be 1, 2, or 3 pole with an integral crossbar to assure simultaneous opening of all poles in multiple circuit breakers. Breakers shall have an overcenter, trip-free, toggle-type operating mechanism with quick-make, quick-break action and positive handle indication. Handles shall have “ON”, “OFF” and “TRIPPED” positions.
3. Circuit breakers shall be UL listed in accordance with UL standard 489 and shall be rated 240 volts ac maximum with continuous current rating as noted on the plans.

4. Branch circuit breakers feeding convenience outlets shall have sensitive instantaneous trip settings of not more than 10 times the trip settings of the breaker to prevent repeated arcing short resulting from frayed appliance cords. Single pole 15 and 20 ampere circuit breakers shall be UL listed as “Switching Breakers” at 120V ac and carry the SWD marking.

5. UL Class A 5mA ground fault circuit protection shall be provided on all receptacle circuits serving wet areas and on all 120V ac branch circuits as specified on the plans or panelboard schedule. This protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection for branch circuit wiring. Tripping of a branch circuit breaker containing ground fault circuit interruption shall not disturb the feeder circuit to the panelboard. A single pole circuit breaker with integral ground fault circuit interruption shall require no more panelboard branch circuit space than a conventional circuit breaker.

6. UL Class B 30mA ground fault circuit protection (GFEP) shall be provided on all equipment circuits requiring ground fault protection. This protection shall be an integral part of the branch circuit breaker which also provides overload and short circuit protection for branch circuit wiring.

7. Provide Shunt Trip Breakers including control power for circuits under cooking hoods and other equipment having this requirement.

8. Provide Breakers with Switched Neutral circuits with common trip for gasoline pumps and other equipment having this requirement.

9. Circuit breakers shall be rated 10,000 AIC at 240V unless otherwise noted on plans or served by transformers greater than 150 kVA.

10. Provide 200% sized neutral bus with panels served from a non-linear transformer and any K4 or higher rated transformers. This shall be a UL approved assembly.

F. Cabinets and Fronts

1. The panelboard bus assembly shall be enclosed in a steel cabinet. The rigidity and gauge of steel to be as specified in UL 50 for cabinets. Wiring gutter space shall be in accordance with UL 67 for panelboards. The box shall be fabricated from galvanized steel or equivalent rust resistant steel. Provide stainless steel front cover for all panels located in all Pool Equipment rooms, Food Labs, Snack Bars, Culinary Arts, Kitchens and Life Skills rooms. All NEMA-1 panels shall have hinged front covers. The front cover shall have a door with hinges, latch and a lock. The piano hinged front covers door-in-door shall allow full access to the circuit breaker gutter area without having to remove the entire front cover. All panelboard lock shall be keyed alike. Circuit breaker and fusible distribution panels shall have four-piece trims. A welded circuit directory frame and card with a clear plastic covering shall be provided on the inside of the door. Provide NEMA 1 enclosure where installed indoors unless otherwise noted. Provide NEMA 3R enclosure where installed outside or in a sprinkled area.

G. Safety Barrier

1. The distribution panelboard interior assembly shall be dead front with panelboard cover removed. Main lugs or main breakers shall have a barrier. The barrier in front of the main lugs shall be hinged to a fixed part of the interior. The end of the bus structure opposite the mains shall have barriers.

H. Integrated Equipment Short Circuit Rating

1. Each panelboard, as a complete unit, shall have a short circuit current rating equal to or greater than the integrated equipment rating shown on the panelboard schedule or on the plans. This rating shall be established by testing with the over-current devices mounted in the panelboard. The short circuit tests on the over-current devices and on the panelboard structure shall be made simultaneously by connecting the fault to each over-current device with the panelboard connected to its rated voltage source. Method of testing shall be per UL 67. The source shall be capable of supplying the specified panelboard short circuit current or greater. Testing of panelboard over-current devices for short circuit rating only while individually mounted is not acceptable. Also, testing of the bus structure alone is not acceptable. Panelboards shall be marked with their maximum short circuit current rating at the supply voltage and shall be UL listed.

I. Metering
1. Provide a branch circuit meter to meter the branch circuits indicated on the drawings. It shall provide kW, kVA, kWh and kVArh. It shall be mounted in the panelboard or externally mounted next to the panel. Communication protocol shall include BACnet or Modbus TCP over ethernet. Connect to the Building Automation System. Program to notify building owner if the load exceeds values set by the energy code indicated on the load analysis. This shall comply with 220.12 Exception No. 1 of the 2017 NEC.

2. Provide a panelboard meter to meter the entire panel as indicated on the drawings. It shall include per phase and total kW, kVA, accumulated kWh, kVArh, power factor, peak demand, frequency, current and voltage. It shall be mounted in the panel board or externally mounted next to the panelboard. Communication protocol shall include BACnet or Modbus TCP over ethernet. Connect to the Building Automation System. Program to notify building owner if the load exceeds values set by the energy code indicated on the load analysis. This shall comply with 220.12 Exception No. 1 of the 2017 NEC.

3. Meters shall be provided with an accuracy of 1.0% and shall be certified to ANSI C12.1.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General: Install panelboards, including electrical connections, in accordance with manufacturers written instructions, NEC and recognized industry practices.

B. All panels shall be mounted to unistrut. Unistrut shall be securely mounted to the floor and structural ceiling. Toggle bolts or anchor bolts attached to drywall is not acceptable.

C. Housekeeping Pads: Mount floor mounted panelboards on 4 inch high concrete housekeeping pads.

D. Fuses: Install fuses of the rating and class as shown in each fusible distribution panel schedule on drawings.

E. Conduits: Stub up three one inch conduits to an accessible location above the ceiling for each recessed panelboard.

3.02 IDENTIFICATION

A. Nameplate: Each panelboard shall have an engraved bakelite nameplate. Nameplates shall be white with black letters and show panel designation. Nameplates shall be attached with stainless steel screws. Refer to Section 26 02 00, paragraph 2.8(C).

B. Directory Card: Cardholders and directory cards shall be furnished for circuit identification in panelboards. Cardholder shall be located on inside of panel door and shall be in a metal frame with clear plastic front. Circuit lists shall be typewritten. Circuit descriptions shall include location and name of each item of equipment served. Spares and spaces shall be written in erasable pencil for future use. Circuit directory shall show the room served by each circuit. The final graphs/signage room numbers shall be used. Do not use Architectural numbering on plans.

C. Replacement Components: Where circuit breakers or fuses are applied in compliance with the series combination ratings marked on the equipment by the manufacturers, the equipment enclosure(s) shall be legibly marked in the field to indicate the equipment has been applied with a series combination rating. The marking shall be readily visible and state "caution - Series Rated System." (NEC 110-22). Nameplate shall also identify replacement components.

D. Replacement Components: Nameplate shall identify replacement components.

3.03 INFRARED SCANNING

A. After Substantial Completion by not more than 2 months after Final Acceptance, perform an infrared scan of each panelboard. Remove fronts if not equipped with viewing ports to make joints and connections accessible to a portable scanner. Submit a copy the owner and engineer for review. If O&M manuals are submitted prior to performance of infrared scan, contractor shall submit a signed letter to verify the scan has been arranged. Letter shall indicate the scan provider and the date It will be performed.

END OF SECTION
SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL
1.01 SCOPE
A. Provide wiring devices as shown; scheduled, required and as specified.
B. The types of wiring devices required include:
   1. Receptacles
   2. Switches
   3. Coverplates

1.02 STANDARDS
A. NEMAWD-1
B. NEMA WD-5
C. UL
D. Federal Spec WC-596-F and WS-896

1.03 ACCEPTABLE MANUFACTURERS
A. Hubbell
B. Leviton
C. Pass & Seymour

1.04 SUBMITTALS
A. Shop drawings shall include but not be limited to:
   1. Cut sheets of all devices indicating NEMA configuration, rating, materials, color, and all accessories.
   2. Cut sheets of all coverplates indicating materials, color and any engraving specified on drawing or in the specifications.

1.05 REQUIREMENTS OF REGULATORY AGENCIES WORK IN ACCORDANCE WITH:
A. National Electric Code.
B. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS
2.01 MATERIALS AND COMPONENTS
A. GENERAL
   1. Provide factory assemble wiring devices with the rating type and color as required and specified for the service indicated.
   2. Provide matching one-piece multiple gang plates where switches are ganged.
   3. Provide wall plates for each receptacle furnished.
   4. Architect reserves the right to select wiring device styles and colors to match wall finish.
   5. Wall plates shall be of same manufacturer as devices.

2.02 SWITCHES
A. Provide specification grade White toggle switches where indicated on the Drawings. Provide "Red" switches for switching emergency lighting circuits where switching is indicated. Coordinate exact locations with architect.
B. Wall switches shall be 20 amp, 120-277 volt and shall be Hubbell, Leviton or P&S as follows:
   1. SINGLE POLE SWITCHES: Hubbell HBL1221, Leviton 1221-2, P&S PS20AC1
   2. DOUBLE POLE SWITCHES: Hubbell HBL1222, Leviton 1222-2, P&S PS20AC2
   3. THREE WAY SWITCHES: Hubbell HBL1223, Leviton 1223-2, P&S PS20AC3
   4. FOUR WAY SWITCHES: Hubbell HBL1224, Leviton 1224-2, P&S PS20AC4
   5. MOMENTARY CONTACT SWITCHES: Hubbell HBL1557, Leviton 1257, P&S 1251
   6. THREE POSITION, TWO CIRCUIT MAINTAINED CONTACT SWITCHES: Leviton 1285, Hubbell HBL1385, P&S 1225
7. KEY TYPE LOCKABLE BARREL KEY OR CORBIN STYLE: Leviton 1221-2KL with 2KL key or P&S PS20AC1-KL with 4609 key for each switch, Hubbell #HBL 1221-RKL
8. Dwelling units shall use Hubbell CS115I, CS120I, P&SCS15AC1, and CS20AC1.
C. Dimmers: Provide Lutron DIVA or as shown on drawings. Wall box dimmers shall be sized to handle the load. Where fluorescent dimming ballasts are to be used, coordinate wall box dimmer with ballast manufacturer.
D. Light Handle Switches: Provide Leviton 1221-LHC, Hubbell HBI1221-II, P&S PS20AC1-ISI lighted handles to switch emergency lights were noted on the drawings.
E. Provide specification grade White decora style rocker switches where indicated on the Drawings. Provide "Red" switches for switching emergency lighting circuits where switching is indicated. Coordinate exact locations with architect.
F. Wall switches shall be 20 amp, 120-277 volt and shall be Hubbell Decorator Series, Leviton, Decora or Pass & Seymour Decorator, as follows:
   1. SINGLE POLE SWITCHES: Leviton 5621-2, P&S 2621, Hubbell DS120
   2. DOUBLE POLE SWITCHES: Leviton 5622-2, P&S 2622, Hubbell DS220
   3. THREE WAY SWITCHES: Leviton 5623-2, P&S 2623, Hubbell DS320
   4. FOUR WAY SWITCHES: Leviton 5624-2, P&S 2624, Hubbell DS420
   5. MOMENTARY CONTACT SWITCHES: Hubbell HBL1557, Leviton 1257, P&S 1251
   6. THREE POSITION, TWO CIRCUIT MAINTAINED CONTACT SWITCHES: Leviton 1285, Hubbell HBL1385, P&S 1225
G. Dimmers: Provide Lutron DIVA wall box dimmers sized to handle the load or as shown on drawings. Where fluorescent dimming ballasts are to be used, coordinate wall box dimmer with ballast manufacturer.
H. Light Handle Switches: Provide Leviton 5649-2 or P&S 2625 lighted handles to switch emergency lights where noted on the drawings.

2.03 RECEPTACLES
A. Provide specification grade White receptacles where indicated on the drawings. Provide "Red" receptacles for receptacles on emergency power. Coordinate exact location with architect.
B. Receptacles shall be Hubbell, Leviton or Pass & Seymour as follows:
   1. Duplex 20A-125V-self grounding with Brass mounting yoke (NEMA configuration 5-20R): Hubbell HBL5352, Leviton 5362, P&S 5362A
   3. Isolated ground duplex, 20A-125V: (Orange, NEMA configuration 5-20R) Hubbell IG5352, Leviton 5362IG , P&S IG5362.
   5. Ground fault circuit interrupter (GFCI) receptacle 20A-125V; (NEMA Configuration 5-20R, shall incorporate self-test, auto monitoring technology and features which will lock-out or render the device incapable of being reset if ground fault protection is compromised, with "Feed through" connectors capable of protecting connected downstream receptacles on a single circuit, and of being installed in a 2-3/4" deep outlet box without adapter, Hubbell GFRST20, Leviton GFNT2 or P & S 2097.
      a. Install Hubbell GFRST20, Leviton GFTR2 or P&S 2097TR Tamper Resistant type for locations requiring Tamper Resistant installations
      b. Install Hubbell GFTWRST20, Leviton GFWR2 or P&S 2097TRWR Weather Resistant type for installations in damp or wet locations
   7. Surge Protection Duplex Receptacles 20A-125V, (NEMA 5-20R) Hospital grade to include LED light and audible alarm: Hubbell HBL8362SA, Leviton 8380, P&S 8300BLSP
   8. Equipment receptacles shall be coordinated with owner/manufacturer requirements and the correct and appropriate receptacle and coverplate shall be installed.
9. Receptacles for dwelling units shall be Hubbell CR15TR and CR20TR tamper resistant receptacles. P&S TR15 and TR20 are an approved equal.

10. USB Charger types receptacles shall be Hubbell, 20A, 125V AC Hospital Grade, Tamper Resistant, with two USB Type 2.0 Ports 5.0 Amp, 5V DC, Decorator Type duplex receptacle. Hubbell USB8300A5 or P&S TR20HUSBAC6.

11. Plug load controlled receptacles shall be Hubbell DR20C2WHI or P&S 26352CDW white and two controlled faces.

12. ARC Fault circuit interrupter receptacles shall be Hubbell AFR20TR or P&S AF202TR.

13. Ground fault circuit interrupter/ARC Fault dual function receptacles shall be Hubbell AFGF20TR or P&S AFGF202TR.

C. Provide specification grade, Decora type White receptacles where indicated on the drawings. Provide “Red” receptacles for receptacles on emergency power. Coordinate exact location with architect.

D. Receptacles shall be Hubbell StyleLine Decorators Series, Leviton, Decora or Pass & Seymour Decorator as follows:

1. Duplex 20A-125V-self grounding: (NEMA configuration 5-20R): Hubbell DR20, Leviton 16362, or P&S 26342.

2. Simplex 20A-125V-Self Grounding: (NEMA configuration 5-20R): Leviton 1635 or P&S 26361.

3. Isolated ground duplex, 20A-125V: (Orange, NEMA configuration 5-20R) Hubbell IG20DRX, Leviton 16362-IG or P&S IG26362 (where X denotes color).

4. Clock hanger receptacle 20A-125V: (Brown with stain finish stainless steel plate with hanger, NEMA configuration 5-20R): Hubbell 5235, Leviton 5361-CH P&S S3733-SS

5. Ground fault circuit interrupter (GFCI) receptacle 20A-125V; GF-5352. (NEMA Configuration 5-20R, shall incorporate self-test, auto monitoring technology and features which will lock-out or render the device incapable of being reset if ground fault protection is compromised, with “Feed through” connectors capable of protecting connected downstream receptacles on a single circuit, and of being installed in a 2-3/4" deep outlet box without adapter, Hubbell GFRST20, Leviton GFNT2 or P&S 2097

   a. Install Hubbell GFTWRST20, Leviton GFWR2 or P&S 2097TRWR Weather Resistant type for installations in damp and wet locations.


7. Surge Protection Duplex Receptacles 20A-125V, (NEMA 5-20R) Hospital grade to include LED light and audible alarm. Hubbell HBL8362SA, Leviton 8380, or P&S 8300SP

8. Special equipment receptacles shall be coordinated with owner/manufacturer requirements and the correct and appropriate receptacle and coverplate shall be installed.

9. USB Charger types receptacles to b Hubbell, 20A, 125V AC Hospital Grade, Tamper Resistant, with two USB Type 2.0 Ports 5.0 Amp, 5V DC, Decorator Type duplex receptacle. Hubbell USB8300A5, P&S TR20HUSBAC6 or equal by other approved wiring device manufacturers.

10. Plug load controlled receptacles to be Hubbell DR20C2WHI or P&S 26352CD white, two controlled faces or equal by Leviton.

11. ARC Fault circuit interrupter receptacles shall be Hubbell AFR20TR

12. Ground fault circuit interrupter/ARC Fault dual function receptacles shall be Hubbell AFGF20TR or P&S AFGF202TR.

2.04 OCCUPANCY SENSORS

A. Provide White dual technology wall mounted sensors, provide one of the following:

1. Single Pole:
   a. Wattstopper #DSW301

2. Double Pole:
   a. Wattstopper #DSW302

3. Dimmer:
   a. Wattstopper #DW311

B. Provide dual technology ceiling sensor with low voltage controlling switch and power pack.
1. Single Button:
   a. Wattstopper # DT300 Sensor, BZ150 Power Pack and LVSW101 Digital Switch
C. Provide Ultra Sonic Ceiling sensor for restrooms.
1. Wattstopper #UT3000, BZ150 Power Pack

2.05 DIGITAL TIMER SWITCHES
A. Provide Wattstopper TS-400-G digital timer. Locate in mechanical, electrical, MDF, and IDF rooms.
B. The time switch shall provide audible notification and visual notification (blink the room lights) prior to turning lights off.
C. The time switch shall have a 12-hour manual override setting.

2.06 PLATES
A. Furnish and install plates on all outlet boxes. Oversize (Jumbo) plates are not acceptable.
B. Plates shall be smooth nylon and 302/304 smooth stainless steel in kitchen and coffee bar areas.
C. Provide Hubbell WP Series, Bell, Carlon or Leviton NEMA 3R weatherproof coverplates on all exterior wiring devices. Enclosure shall be suitable for wet locations when in use.
D. Plates shall be Hubbell SS Series, Leviton, Pass & Seymour 302/304 smooth stainless steel on all receptacles 30 amps and larger.
E. Stainless steel device plates shall be provided at locations with tile or stone walls.

2.07 FLOOR BOXES WITH SURFACE ACTIVATION SHALL BE CAST IRON AS MANUFACTURED BY HUBBELL OR EQUAL BY WIREMOLD 880CS/CM SERIES AND AS INDICATED BELOW:
A. Slab at grade (dual level, fully adjustable type I).
   1. Single gang: #B-2436 w/#SB-3083 carpet flange.
   2. Two gang: #B-4233 w/#SB-3084 carpet flange.
   3. Three gang: #B-4333 w/#SB-3085 carpet flange.
B. Slab above grade (shallow, fully-adjustable, type II)
   2. Two gang: #B-2422 w/#SB-3084 carpet flange.
   3. Three gang: #B-2423 w/#SB-3085 carpet flange.
C. Cover plates shall have brass finish as follows:
   1. #S-3825 for duplex flap for duplex receptacles.
   2. #S-3826 for data/communications.

2.08 PVC FLOOR BOXES MANUFACTURED BY HUBBELL OR EQUAL SHALL BE AS FOLLOWS:
A. Provide CFBS1R4CFB dual service cast iron body floor box with PVC riser. Provide CFBS1R4CUP adjustable mounting cup, S1R4SP2X2DUPLEX sub-plate for (1) Duplex and (2) RJ-45 Keystone jacks OR S1R4SP2X2STYLE for (1) GFCI duplex, USB or Surge Device & (2) Keystone jacks, OR S1R4SPQUAD sub-plate with (4) 20A simplex receptacles, single and dual circuit wiring capability. Provide with CFBS1R4CVR cover, Color to be chosen by Architect.
   1. NOTE TO SPECIFIER: Minimum depth of pour 5-inches, Maximum is 6-inches
   2. Maximum finished floor thickness (above top of box collar) with maximum adjustability is 1-1/2-inches at 5-inch, at 6-inches maximum adjustability is 1/2”.

2.09 FLOOR BOXES, RECESSED ACTIVATION TYPE, MEET UL 514A SCRUB WATER REQUIREMENTS, SHALL BE STAMPED STEEL WITH CORROSION RESISTANT FINISH, UL LISTED FOR SLAB-ON-GRADE INSTALLATIONS, OR STAMPED STEEL FOR ABOVE-GRADE INSTALLATIONS AS MANUFACTURED BY HUBBELL OR EQUAL BY WIREMOLD RFB2-11 SERIES AND AS INDICATED BELOW:
A. Recessed Activation Slab at grade:
   1. Two gang: #CFB2G30CR or CFB2G30RCR (provisions for round cover), capable of up to 2’ entry per gang. Flush flange, Surface flange and Furniture Feed cover availability. Surface Type Covers shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past 0.15” rise
2. Four Gang: #CFB4G30CR or CFB4G30RCR (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Cover shall not exceed 0.15" rise. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.

3. Six Gang: #CFB6G30CR or CFB6G30RCR (provisions for round cover), capable of up to 2" entry per gang. Flush flange, Surface flange availability. Surface Type Covers shall not exceed 0.15" rise. Covers with provisions for cable egress, when in use, shall maintain the 0.15" rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15" rise.

4. Ten Gang AV: #CFB10G55CR or CFB10G55RCR (provisions for round cover), with minimum (2) 2 KO’s, multiple front and back 3/4” to 1-1/2” concentric KO’s. Flush flange, Surface flange availability. Cover shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15” rise.

B. Recessed Activation

1. Two Gang: #CFB2G30 or CFB2G30R (provisions for round cover), capable of up to 2” entry per gang. Flush flange, Surface flange and Furniture Feed cover availability. Surface Type Covers shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15” rise.

2. Four Gang: #CFB4G30 or CFB4G30R (provisions for round cover), capable of up to 2” entry per gang. Flush flange, Surface flange availability. Cover shall not exceed 0.15” rise. Surface Type Covers shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15” rise.

3. Six Gang: #CFB6G30 or CFB6G30R (provisions for round cover), capable of up to 2” entry per gang. Flush flange, Surface flange availability. Surface Type Covers shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall maintain the 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15” rise.

4. Ten Gang AV: #CFB10G55 or CFB10G55R (provisions for round cover), with minimum (2) 2 KO’s, multiple front and back 3/4” to 1-1/2” concentric KO’s. Flush flange, Surface flange availability. Cover shall not exceed 0.15” rise. Covers with provisions for cable egress, when in use, shall not exceed/extend past the 0.15” rise.

C. Service Fittings

1. Surface Style Rectangular for use with carpet, tile, VCT and other engineered floors, available with or without carpet insert and offer system’s furniture feed type cover providing (1) 1-inch and (1) 2-inch threaded openings

2. Flush Style Rectangular for use with tile, finished concrete or Terrazzo floors, available with or without carpet insert and offer system’s furniture feed type cover providing (1) 1-inch and (1) 2-inch threaded openings

3. Rectangular covers shall be powder coated in variety of common finishes, Aluminum, Black, Brass, Bronze and Satin Nickel.

4. Round Covers for use with all floor types Shall provide cable egress doors and systems furniture feed type cover providing (1) ½-inch and (1) 2-inch threaded openings Round covers shall be plated metal in variety of finishes except Black (powder coated) Brushed Aluminum, Brass Plated, Bronze Plated, Satin Nickel Plated.

2.10 FIRE RATED POKE THROUGH DEVICES SHALL BE AS FOLLOWS:

A. Installations requiring 4-inch cored openings, poke thru devices shall be manufactured by Hubbell or approved equal, Hubbell S1R4PTFIT Recessed Activation poke thru with either S1R4SP2X2STYLE or S1R4SP2X2DUPLEX sub-plate for (1) 20A Duplex, GFCI OR USB 2 Port Duplex with (2) openings for (2) RJ-45 Jacks with S1R4CVR - color to be chosen by Architect.

B. Installations requiring 6-inch cored openings, with duplex power, shall be manufactured by Hubbell or Wiremold 6AT, Hubbell S1R6PTWZ-XXX Recessed Activation poke thru which includes S1R6SPW and S1R6SPZ sub plates and S1R6CVR cover, where XXX is finish. Color to be chosen by Architect. This includes (1) pre-wired 20A, 125 V duplex receptacle and (2) NEMA configured rectangular Decorator openings for telephone, signal or up to (12) Category 5e/Cat 6 RJ-45 Jacks.

C. Installations requiring 6-inch cored openings, with quad power, shall be manufactured by Hubbell or Wiremold 6AT, Hubbell S1R6PTDEH-XXX Recessed Activation poke thru which includes S1R6SPH and S1R6SPE sub-plates and S1R6CVR cover where XXX is finish.
PART WIRING

3. Devices - Unless installed-

The location of devices shall be furnished by the Architect or the Contractor and shall be coordinated with the Owner. Devices shall be installed in walls covered with vinyl, fabric wallpaper or other special finishes shall be coordinated and verified with the Architect on the job-site.

3.01 WIRING DEVICE MOUNTING HEIGHTS

A. Switches 42" above finished floor.
B. Wall mounted receptacles shall be installed vertically at 15 inches to the bottom outlet above finished floor unless otherwise noted or as required by local codes.
C. Wall telephone outlets shall be mounted 15 inches to the bottom above finished floor unless otherwise noted. Mount even with wall mounted receptacles.
D. At locations above counters, set devices at 6 inches above to the centerline counter tops, verify exact mounting height with the architect.

3.02 INSTALLATION (REFER TO 26 05 33 FOR OUTLET BOX SPECIFICATIONS).

A. Wall switches shall be set in a suitable steel box and shall be installed on the strike side of the door as finally hung, whether so indicated on the Drawings or not.
B. Receptacles shall be installed in a suitable steel box.
C. The Architect reserves the right to relocate wiring device up to a distance of 5 feet from the location shown, before rough-in, without additional cost.
D. Provide multi-gang device covers at locations where devices gang together.
E. Device locations are indicated schematically on the drawings along with the type and mounting height. Final locations and mounting heights shall be coordinated with the Architect on the jobsite, and with shop drawings of equipment; including equipment to be furnished and installed by the Owner. Devices installed in walls covered with vinyl, fabric wallpaper or other special finishes shall be coordinated and verified with the Architect on the job-site.
F. Stranded wire termination to switches, receptacles, devices and miscellaneous control devices shall be with an approved solderless terminal if clamp type securing is not possible (i.e. Sta-Con crimp on fork tongue connectors; Burndy Type TP-F).
G. Provide keyed switches in all common areas not monitored by the faculty (i.e. gym, corridors, cafeteria, commons natatoriums).
H. Tamper-resistant type receptacles shall be installed in all classrooms, cafeterias, corridors, special education, ALE, computer labs, special use classroom and all spaces where children 7 years and younger may occupy. In Child-Care facilities, tamper resistant receptacles shall be provided for all spaces with exception to back-of-house spaces, such as kitchens, custodial closets, electrical and mechanical rooms.
I. All 20A, 120V receptacles in food service areas shall be GFCI.
J. All circuit breaker serving electric drinking fountains shall be GFCI.
K. Provide ARC Fault circuit interrupters (AFCI) as required to comply with 210.12 of the N.E.C. This shall include but not be limited to dwelling units and dormitories. AFCI breakers may be used.
L. Provide ground fault circuit interrupter (GFCI)/ARC Fault circuit interrupter (AFCI) dual function receptacles to comply with 210.8, 210.12 and 406.4 of the N.E.C.

END OF SECTION
SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.01 SCOPE
   A. Provide fuses as shown and scheduled and indicate by this specification section and other specifications sections.
   B. The type of fuses include:
      1. 600 volt current limiting.
      2. 250 volt current limiting.

1.02 STANDARDS
   A. ANSI
   B. UL

1.03 ACCEPTABLE MANUFACTURERS
   A. Eaton Bussmann
   B. Merson

1.04 SUBMITTALS
   A. Shop drawings shall include, but not be limited to:
      1. Cutsheets of all fuses showing ratings and fuse curves.

1.05 REQUIREMENTS OF REGULATORY AGENCIES
   A. WORK IN ACCORDANCE WITH:
      2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.01 CURRENT - LIMITING FUSES
   A. General: Provide 200,000 amp interrupting capacity current limiting fuses of the ampacity and voltage indicated and scheduled.
   B. Mains, Feeders and Branch Circuits
      1. Circuits 601 to 6000 ampere shall be protected by current limiting BUSSMANN HI-CAP Time Delay Fuses KRP-C. Fuses shall employ "O" ring as positive seals between the end bells and the glass melamine fuse barrel. The terminals shall be peened. Fuses shall be time-delay and must hold 500% of rated current for a minimum of 4 seconds, clear 20 times rated current in .1 seconds or less and be listed by Underwriters’ Laboratories Inc., with an interrupting rating of 200,000 amperes r.m.s. symmetrical. The fuses shall be UL Class L.
   C. Class J Fuses
      1. Circuits 0 to 600 ampere shall be protected by current limiting BUSSMANN LOW-PEAK Dual Element Fuses LPJ. All dual-element fuses shall have separate overload and short-circuit elements. Fuse shall incorporate a spring activated thermal overload element having a 284 degree Fahrenheit melting point alloy and shall be independent of the short-circuited clearing chamber. The fuse must hold 500% of rated current for a minimum of 10 seconds and listed by Underwriters’ Laboratories Inc., with an interrupting rating of 200,000 amperes rRMS symmetrical. The fuses shall be UL Class J.
      2. Motor Circuits - All individual motor circuits rated 600 amperes or less shall be protected by BUSSMANN LOW-PEAK LPJ. The fuses for 1.15 service factor motors shall be installed in ratings approximately 125% of motor full current except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions the fuse should be 150% to 200% of the motor full load current. Larger H.P. Motor shall be protected by BUSSMANN Type KRP-C HI-CAP Time-Delay Fuses of the rating shown on the drawings. 1.0 service factor motors shall be protected by BUSSMANN LOW-PEAK Dual-Element Fuses LPJ installed in ratings approximately
115% of the motor full load current except as noted above. The fuses shall be UL Class LPJ or L. Circuit breaker panels shall be protected by BUSSMANN LOW-PEAK Dual-Element LPJ as shown on the drawings. The fuses shall be UL Class J.

D. Class RK1 Fuses
1. Circuits 0 to 600 ampere shall be protected by current limiting BUSSMANN LOW-PEAK Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts). All dual-element fuses shall have separate overload and short-circuit elements. Fuse shall incorporate a spring activated thermal overload element having a 284 degree Fahrenheit melting point alloy and shall be independent of the short-circuited clearing chamber. The fuse must hold 500% of rated current for a minimum of 10 seconds and listed by Underwriters' Laboratories Inc., with an interrupting rating of 200,000 amperes RMS symmetrical. The fuses shall be UL Class RK1.
2. Motor Circuits - All individual motor circuits rated 600 amperes or less shall be protected by BUSSMANN LOW-PEAK Dual Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts). The fuses for 1.15 service factor motors shall be installed in ratings approximately 125% of motor full current except where high ambient temperatures prevail, or where the motor drives a heavy revolving part which cannot be brought up to full speed quickly, such as large fans. Under such conditions the fuse should be 150% to 200% of the motor full load current. Larger H.P. Motor shall be protected by BUSSMANN Type KRP-C HI-CAP Time-Delay Fuses of the rating shown on the drawings. 1.0 service factor motors shall be protected by BUSSMANN LOW-PEAK Dual-Element Fuses LPN-RK (250 volts) or LPS-RK (600 volts) installed in ratings approximately 115% of the motor full load current except as noted above. The fuses shall be UL Class RK1 or L.
3. Circuit breaker panels shall be protected by BUSSMANN LOW-PEAK Dual-Element LPN-RK (250 volts) or LPS-RK (600 volts) as shown on the drawings. The fuses shall be UL Class RK1.

2.02 SPARES
A. Upon completion of the building the contractor shall provide the owner with spare fuses as shown below.
   1. 10% (minimum of 3) of each type and rating of installed fuses shall be supplied as spares.
   2. BUSSMANN spare fuse cabinets - Catalog No. SFC - shall be provided to store the above spares.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Fuses: Fuses shall not be installed until equipment is ready to be energized. This measure prevents fuse damage during shipment of the equipment from the manufacturer to the job-site or from installation. All fuses shall be furnished and installed by the electrical contractor. All fuses shall be of the same manufacturer.
   B. All fuses shall be installed in fuse holders.

END OF SECTION
SECTION 26 28 16

SAFETY AND DISCONNECT SWITCHES

PART 1 - GENERAL

1.01 SCOPE
A. Provide safety and disconnect switches as shown, scheduled and as specified herein.

1.02 STANDARDS
A. Products shall be designed, manufactured, tested and installed in compliance with applicable standards.
   1. NEMA KS1 - Enclosed switches
   2. Federal specification W-S-865C-Heavy duty switches
B. Products shall conform all applicable UL standards, including UL98 (standard for safety, enclosed and dead front switches) and shall be UL-labeled.

1.03 ACCEPTABLE MANUFACTURERS
A. Provide one of the following manufacturers:
   1. General Electric Company
   2. Square D Company
   3. Siemens
   4. Eaton

1.04 SUBMITTALS
A. Shop drawings shall include, but not be limited to:
   1. Cutsheets of switches with ratings, physical dimensions and all accessories clearly labeled.

1.05 REQUIREMENTS OF REGULATORY AGENCIES
A. WORK IN ACCORDANCE WITH:
   2. Local, municipal, or state codes that have jurisdiction.

PART 2 - PRODUCTS

2.01 GENERAL
A. Furnish and install heavy duty type safety switches with the number of switched poles as indicated on the plans and specifications. All safety switches shall be NEMA Heavy Duty Type HD, and Underwriters Laboratories listed.

2.02 MATERIALS AND COMPONENTS
A. Switch Interior
   1. All switches shall have switch blades that are fully visible in the "OFF" position when the door is open. Switches shall have removable arc suppressor where necessary, to permit easy access to line side lugs. Lugs shall be front removable and UL listed for 60ºC and 75ºC copper or aluminum cables. All switches blades and contacts shall be plated copper. Adjust fuse block to accept Class J fuses.

B. Switch Mechanism
   1. Switches shall have a quick-make and quick-break operating handle and mechanism, which shall be an integral part of the box, not the cover. Padlocking provisions shall be provided for locking in the "OFF" position with at least three padlocks. Switches shall have a dual cover interlock to prevent unauthorized opening of the switch door when the handle is in the "ON" position, and to prevent closing of the switch mechanism with the door open. A means shall be provided to permit authorized personnel to release the interlock for inspection purposes. Handle position shall indicate if switch is "ON" or "OFF".

C. Neutral
   1. Provide a solid neutral with the safety switch where a neutral is present in the circuit.

D. Ratings
1. Switches shall be horsepower rated for ac and/or dc as indicated by the plans. The fused switches shall have Class R rejection fuse clips or adjusted for Class J fuses. UL listed short circuit ratings of the switches, when equipped with Class R fuses, shall be 200,000 symmetrical amperes.

E. Enclosures
1. Indoor switches shall be furnished in NEMA 1 enclosures.
2. Outdoor switches, switches located in wet areas or sprinkled areas shall be furnished in NEMA 3R enclosures.
3. Switches installed in wet areas such as cooling tower areas shall be NEMA 4X stainless steel or fiberglass reinforced polyester.
4. Switches installed in kitchens shall be stainless steel.
5. Switches installed in areas of a corrosive nature and subjected to salt air shall be NEMA 4X stainless steel or fiberglass reinforced polyester.

F. Electrical Interlock Contacts
1. Provide electrical interlock contacts on all disconnect switches serving motors in which remote VFDs are serving the motor. Provide conductors from contacts to the safe circuit inside the VFD. De-energizing the disconnect switch shall signal VFD to stop.

G. Service Entrance
1. Switch shall be suitable for use as service entrance equipment when installed in accordance with the National Electrical Code.

PART 3 - EXECUTION

3.01 GENERAL
A. Install safety and disconnect switches, including electrical connections, and fuses in accordance with manufacturer's written instructions, NEC and recognized industry practices.
B. Location: Install switches within sight of controllers.
C. Hubs: Provide bolt-on hubs for rainproof or wet area applications.

3.02 IDENTIFICATION
A. Nameplate: Each disconnect switch shall have an engraved bakelite nameplate. Nameplates shall be white with black letters and show equipment served. Nameplates shall be attached with stainless steel screws.

END OF SECTION
SECTION 26 29 26
MISCELLANEOUS ELECTRICAL CONTROLS AND WIRING

PART 1 - GENERAL
1.01 GENERAL REQUIREMENTS
A. The requirements of the General Conditions and Supplementary Conditions apply to all work herein.

1.02 SCOPE
A. Provide the various miscellaneous control devices, wiring and additional branch circuits as required, shown and specified.
B. The types of miscellaneous control devices and wiring include but not limited to the following:
   1. Contactors
   2. Relays
   3. Photocells
   4. Time switches
   5. Additional control wiring and safety devices as shown and specified.
   6. Connect power from fire alarm relays to starters to shut down air handling units.
C. WORK SPECIFIED ELSEWHERE:
   1. Various control devices, of an electrical nature, for the safe operation and temperature control of the heating, ventilating, air conditioning and plumbing systems provided under Division 22 and Division 23.
   2. All control wiring and conduit shall be furnished under Division 23. All power wiring 120 volt or larger shall be provided by Division 26.
   3. Refer to building controls specification, Division 23 for scope of work required to be performed by Division 26 (electrical contractor).

1.03 REQUIREMENTS OF REGULATORY AGENCIES
A. WORK IN ACCORDANCE WITH:
   2. Local municipal or state codes that have jurisdiction.

1.04 ACCEPTABLE MANUFACTURERS
A. Provide one of the following manufacturers:
   1. LIGHTING CONTACTORS AND RELAYS
      a. General Electric
      b. Square D Company
      c. Automatic Switch Company
   2. PHOTOCELLS AND TIME SWITCHES
      a. Tork, Inc.
      b. Intermatic time controls
      c. AMF paragon

PART 2 - PRODUCTS
2.01 MATERIAL
A. GENERAL: This Section shall outline the basic installation of electric devices, conduit, boxes, fittings, and wiring required for complete interconnection of several systems, this may not reflect every required appurtenance. It does not cover integral parts of mechanical equipment.
B. CONTACTORS AND RELAYS: Provide control wiring, contactors, and relays with the ampere-rating and number of poles as shown, specified, and required for a complete and functioning system:
   1. Rated at 600 volts, 60 hertz.
   2. Continuously rated contacts for all types of ballast and tungsten lighting, resistance and motor loads. Contacts shall be sized as scheduled or noted.
   3. Shall have totally enclosed, double-break silver-cadmium-oxide power contacts. Auxiliary arcing contacts are not acceptable. Contact inspection and replacement
shall be possible without disturbing line or load wiring.
4. The contactor shall have straight-through wiring with all terminals clearly marked.
5. The contactor shall be approved per UL508 and/or CSA, and be designed in accordance with NEMA ICS2-21 B.
6. They shall be industrial-duty rated for applications to 600 volts maximum.
7. The contactor shall have provisions for factory or field addition of:
   a. Four (4) N.O. or N.C. auxiliary contacts rated 6 amperes continuous at 600 volts.
   b. Single or double circuit, N.O. or N.C., 30 or 60 ampere 600 volt power-pole adder.
8. The contactor shall have a NEMA type 1 enclosure unless otherwise noted.
9. Control power to the contactor 120V control circuit shall be provided from the nearest panelboard 120V circuit. If the 120V control power circuit is not shown, provide a control power transformer for 120 volt control power and a 120 volt coil when required for control. Provide primary and secondary fuses on the control power transformer.
10. Electrically Held Lighting - Contactor coils shall be continuously rated and encapsulated. Electrically held contactors are not to be used unless specifically shown on the plans.
11. Mechanically Held Lighting Contactors - Coil-clearing contacts shall be supplied so that the contactor coils shall be energized only during the instance of operation. Both latch and unlatch coils shall be encapsulated. All contactors shall be mechanically held unless noted otherwise on the plans.
12. Provide 2-wire or 3-wire control modules as required to operate lighting contactors.
13. Provide hand-off-automatic controls (H-O-A) for each lighting contactor.
14. Provide relays and contactors to shut down air handling units.

C. Photocells: Provide a specification grade self-contained, weatherproof, photoelectric control that shall be mounted on an FS type weatherproof junction box. The photocell shall:
   1. Switch "ON" at dusk and "OFF" at dawn.
   2. Adjustable from 2 to 50 foot-candles.
   4. Use 1" diameter cadmium sulphide cell.
   5. Have a 2-minute delay to prevent false switching.

D. TIME SWITCHES: Provide a 7-day digital time clock with battery back-up feature installed in a NEMA 3R enclosure.

E. Control wiring shall be not less than #14 AWG type TW and shall be color coded and labeled with Brady markers throughout. Bundle multiple conductors with Ty-Raps.

PART 3 - EXECUTION
3.01 INSTALLATION
A. Install miscellaneous electrical controls and wiring to provide a functioning system.
B. Install contactor and relays in electrical/mechanical rooms unless otherwise noted.
C. Install photocells on the roof unless otherwise directed by the architect. Coordinate any roof penetrations with all other trades and shield from other light sources.
D. Provide miscellaneous connections for signs and other furnished equipment as shown on the Drawings.

3.02 DIVISION 22, 23, 27 AND 28 MISCELLANEOUS POWER AND CONTROLS
A. Install electrical devices not an integral part of system equipment providing conduit, boxes, fittings, wiring, circuit breakers, disconnecting means and other devices.
B. Contractor is responsible for providing all line voltage power to devices that require electrical power to operate. Contractor shall terminate line voltage power to termination points. Contractor shall coordinate between all trades to determine sizing and quantities of line voltage circuits to adequately power and control devices. Provide circuits from nearest low voltage panel using spare circuits provided, if device requires power not already available or indicated.
C. Provide GFCI receptacle with weather proof cover within 25 feet of all heating, air conditioning and refrigeration equipment.
3.03 OPERATIONS PERSONNEL TRAINING

A. Provide a training session for the owner’s operations personnel. Training session shall be performed by a qualified person who is knowledgeable in the subject/equipment. Submit a training agenda two (2) weeks prior to the proposed training session for review and approval. Training session shall include at the minimum:

1. Purpose of equipment.
2. Principle of how the equipment works.
3. Important parts and assemblies.
4. How the equipment achieves its purpose and necessary operating conditions.
5. Most likely failure modes, causes and corrections.
6. On site demonstration.

END OF SECTION
SECTION 26 43 13.13

SURGE PROTECTIVE DEVICES ( SPD) - STANDARD INTERRUPTING

PART 1 - GENERAL

1.01 SCOPE

A. Specify the electrical and mechanical requirements for a non-modular high-energy surge protective device system ( SPD). The specified system shall provide effective high energy surge current diversion and be suitable for application in ANSI/IEEE C62.41 Category A, B and C3 environments, as tested by ANSI/IEEE C62.11, C62.45.

B. The system shall be constructed using multiple surge current diversion modules utilizing metal oxide varistors ( MOV) computer matched to +/- 1-volt variance and tested for manufacturer’s defects. The modules shall be designed and constructed in a manner that ensures surge current sharing. Use of gas tubes, silicon avalanche diodes or selenium cells are unacceptable. Devices shall utilize a minimum of three (3) MOV’s fuse links pair per phase. This will allow greater than 50% redundant protection in if a MOV fails.

C. Third Party Test Report verifying surge current rating, longevity, testing, and filtering capabilities shall be provided with submittal.

1.02 STANDARDS

A. The specified system shall be designed, manufactured, tested and installed in compliance with the following codes and standards:
   1. Canadian Standards Association ( CSA or CUL)
   2. American National Standards Institute and
   3. Institute of Electrical and Electronic Engineers ( ANSI/IEEE C62.11, C62.41, C62.45)
   4. Institute of Electrical and Electronic Engineers 1100 Emerald Book
   5. Federal Information Processing Standards Publication 94 ( FIPS PUB 94)
   7. National Fire Protection Association ( NFPA 20, 70, 75 and 780)
   10. Revisions ( June 1, 2009)
   11. International Electrotechnical Commission ( IEC 801)

B. The systems individual units shall be UL/ ANSI Listed and labeled under UL 1449 ( Fourth Edition) Standard for Surge Protection Devices Type 2 20kA with a nominal discharge current of 20kA and the surge ratings shall be permanently affixed to the SPD. The units shall also be listed and labeled to UL1283 for type 2 locations Standard for Electromagnetic Interference Filters, and CSA/CUL Listed.

1.03 ACCEPTABLE MANUFACTURERS

A. Southern Tier Technologies

1.04 SUBMITTALS

A. Shop drawings shall include, but not be limited to:
   1. Cutsheets of surge protection devices with ratings, physical dimensions and all accessories clearly labeled.
   2. Device labels shall be clearly indicated in cutsheets.
   3. All standards and listings, as specified in section 1.2A-B, shall be clearly labeled in cutsheets provided.
   4. Cutsheets shall clearly outline that design requirements of this specification have been met.

1.05 QUALITY ASSURANCE

A. The manufacturer shall be ISO 9001 certified. The specified system shall be tested at the component and fully assembled level, under surge conditions with AC power applied for a minimum of 1 hour. Testing shall include but not be limited to quality control checks.
dielectric voltage withstand test per UL and CSA requirements, UL ground continuity tests and operational and calibration tests.

B. The unit shall be designed and manufactured in the USA by a qualified manufacturer of surge protection equipment and Active Tracking Filters. The manufacturer shall have been engaged in the design and manufacture of such products for a minimum of 10 years.

PART 2 - PRODUCTS

2.01 ENCLOSURE

A. The specified system shall be provided in a heavy duty NEMA 4 or better dust-tight, drip-tight enclosure with no ventilation openings.

2.02 OVERCURRENT PROTECTION (FUSING)

A. Individual surge components shall be fused to prevent violent failure. The fusing shall be UL listed and shall be capable of interrupting up to 200kA symmetrical fault current with 480VAC applied. Replaceable fusing is unacceptable. Overcurrent protection that limits specified surge currents is not acceptable. Devices that utilize a single fuse to protect two or more suppression paths are not accepted.

2.03 DESIGN REQUIREMENTS

A. Protection Modes:
   1. The SPD shall provide protection as follows: All modes, L-N or L-L, L-G and N-G (where applicable) Note: L = Line, G = Ground, N = Neutral

B. UL 1449 Ratings:
   1. The maximum UL/ANSI 1449 listed surge ratings for each and/or all of the specified protection modes shall not exceed the following in any mode of protection:

<table>
<thead>
<tr>
<th>System Voltage</th>
<th>Voltage Protection Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L-N</td>
</tr>
<tr>
<td>120/240</td>
<td>600-volts</td>
</tr>
<tr>
<td>120/208</td>
<td>600-volts</td>
</tr>
<tr>
<td>240</td>
<td></td>
</tr>
<tr>
<td>277/480</td>
<td>1200-volts</td>
</tr>
<tr>
<td>480</td>
<td>1800-volts</td>
</tr>
</tbody>
</table>

C. Noise Attenuation:
   1. The unit shall be UL 1283 Listed as an electromagnetic interference filter in type 2 locations. The filter shall provide insertion loss with a maximum of 60 dB from 100 KHz to 100 MHz per 50 Ohm Insertion Loss Methodology from MIL 220A. The system shall provide up to 120 dB insertion loss from 100 KHz to 100 MHz when used in a coordinated facility system.

D. Life Cycle Testing:
   1. The SPD system shall be duty life cycle tested to survive 6,000 20kV, 10kA Surges, per IEEE C62.41 Category C3 surge current with less than 5% degradation of clamping voltage.

2.04 CONNECTIONS

A. Provide 60” wire leads #10 AWG or UL 1449 tested size.

2.05 STANDARD FEATURES

A. Unit Status Indicators:
   1. Red and green solid state indicators with printed labels shall be provided on the front cover to redundantly indicate on-line unit status including N-G monitoring. The absence of the green light and the presence of the red light shall reliably indicate that surge protection is reduced and service is needed to restore full operation.

B. Dry Contacts for remote monitoring:
   1. Electrically isolated Form C dry contacts, one normally open and one normally closed set standard on all units for remote monitoring.

C. Undervoltage detection:
   1. Unit shall be equipped with 70% undervoltage detection capability.

D. Phase Loss Monitoring:

Surge Protective Devices ( SPD) - Standard Interrupting
1. Unit shall be equipped with phase loss monitoring.

E. Power Loss Monitoring:
   1. Unit shall be equipped with power loss monitoring.

2.06 TESTING
A. Component Testing and Monitoring:
   1. Unit shall include an on-line circuit which tests and redundantly monitors individual components in all protection modes including neutral to ground (where applicable). Units that require external test sets or equipment are not acceptable.

2.07 ENVIRONMENTAL REQUIREMENTS
A. Storage Temperature: -55 to +85 C (-67 to +187 F)
B. Operating Temperature: -40 to +60 C (-40 to 140 F)
C. Relative Humidity: 0% to 95%
D. Audible Noise: less than 45 dBA at 5 feet (1.5 m).
E. Operating Altitude: 0 to 18,000 feet above sea level.

2.08 WARRANTY
A. The manufacturer shall provide a full 10 year parts and a 5 year labor warranty from date of shipment against any part failure when installed in compliance with manufacturer’s written instructions, UL Listing requirements and any applicable national, state or local electrical codes. Direct, factory trained, ISO 9001 certified employees must be available for 48 hour assessment. A 24 hour 800 number must be available to support warranty.

2.09 PART 3 - EXECUTION
A. INSTALLATION
   1. Install the parallel SPD with short and straight conductors as practically possible. Locate adjacent to the switchboard or panel it is serving. The contractor shall twist the SPD input conductors together to reduce input conductor inductance. The contractor shall follow the SPD manufacturer’s recommended installation practices as found in the installation, operation and maintenance manual and comply with all applicable codes. Provide STT Tierguide cable if the cable length exceeds 5 feet from the circuit breaker servicing the SPD.
   2. Provide Flush Mount Stainless Steel Cover Kit for kitchen areas.
   3. Provide Flush Mount Cover Kit for residential units and hotel suites.

END OF SECTION
SECTION 28 46 00.13
FIRE ALARM AND SMOKE DETECTION SYSTEM

PART 1 - GENERAL
1.01 SCOPE
A. The contractor shall design, furnish and install a complete microprocessor based 24VDC, electrically supervised, analog intelligent fire alarm system as specified herein and provide drawings. The system shall include, but not be limited to, all control equipment, power supplies, signal initiating and signaling devices, conduit, wire, fittings, and all other accessories required to provide a complete and operable system.
B. The system shall operate as a non-coded, continuous sounding system, which will sound alarm devices until manually silenced, as herein specified.
C. The system shall be wired as a style B and style 4 supervised system for all circuits.

1.02 CODES AND STANDARDS
A. The system shall comply with the applicable Codes and Standards as follows:
   2. National Fire Protection Association Standards: NFPA 70 NEC
      a. NFPA 72 National Fire Alarm Code (current State adopted version) NFPA 90A Air Conditioning
      b. UL 1971 Visual Devices Visual Devices
      c. ANSI 117.1
   3. Local & State Building Codes
   4. Requirements of Local Authorities having Jurisdiction. If local authorities design requirements differ substantially from contract drawings, the design engineer shall be notified no less than 10 days prior to bid date, to allow time for addendum to be provided to all contractors. Contractor to provide additional devices as required by local authorities in bid pricing.
   5. Underwriters Laboratory Requirements and Listings for use in Fire Protective
B. Signaling Systems as follows:
   1. UL 864 Control Panels 9th Edition UL 268 Smoke Detectors - Systems UL 268A Duct Smoke Detectors
   2. UL 521 Heat Detectors
   3. UL 228 Door Holder-Closers

1.03 ACCEPTABLE MANUFACTURERS
A. To establish the type, quality, and features of system required, the equipment specified is that of the Notifier Fire Systems.
B. All equipment, materials, accessories, devices, etc. covered by the specifications and/or noted on the contract drawings shall be new and unused and be U.L. listed for their intended use.
C. All references to manufacturer or supplier’s model numbers and other pertinent information herein is intended to establish a minimum standard of quality, performance and features required. All equipment proposed as an EQUAL to that specified shall COMPLETELY conform to the specifications herein.
D. Equipment of other manufacturer’s or supplier’s may be considered as an equal to that specified provided that completely marked and identified catalog sheets of all proposed equipment is provided to the architect/engineer for review ten (10) days prior to the date of bid for evaluation. In addition, a list of the contractor’s qualifications and any exceptions to the specifications must be provided for review. Approval for any such substitution of equipment must be obtained in writing from the architect/engineer five (5) days prior to bid.
E. Provide one of the following manufacturers:
   1. Notifier Fire Systems
   2. Siemens
   3. Edwards System Technology (EST)
1.04 GENERAL REQUIREMENTS
A. Contractor Qualifications:
   1. The equipment supplier shall be an authorized and designated representative of the Fire Alarm Manufacturer to sell, install, and service the proposed manufacturer’s equipment.
   2. The equipment supplier and installing contractor shall be licensed by the State
      a. Fire Marshall to sell, install, and service fire alarm systems as required by Article 543-2 of the Texas Insurance Code.
   3. The installing contractor and/or equipment supplier shall have on his staff a minimum of three (3) installation superintendents who are licensed by the State Fire Marshall’s office for such purpose and under whose supervision installation, final connections, and check out will take place as required by the Texas Insurance Code.
   4. The installing contractor or equipment supplier shall have on staff a minimum of one (1) certified NICET Level III state licensed fire alarm planner under whose supervision system design shall take place.
   5. The installing contractor shall provide 24 hour, 365 days per year emergency service with qualified and state licensed service technicians.
   6. The installing contractor shall have been actively engaged in the business of selling, installing, and servicing fire alarm systems for at least ten (10) years.

1.05 SUBMITTALS
A. The installing contractor and/or equipment manufacturer shall provide complete and detailed shop drawings and include:
   1. Control panel configuration including wiring and interconnection schematics.
   2. Complete point to point wiring diagram showing terminal connections to all system devices.
   3. Riser wiring diagram and associated zoning/addressing configurations with associated conduit sizes.
   4. Complete floor plan drawings locating all devices associated with the fire alarm system. Floor plan drawings shall include conduit and wiring routing complete with conduit sizing and number of conductors by type.
   5. Factory data sheets on each piece of equipment to be used and so marked as to model, dimensions, size, voltage, and configuration.
   6. Detailed system description in this specification format describing system functions and operation. All specification variations and deviations shall be clearly noted and marked.
   8. Programming matrix defining all input/output functions and zoning.
   9. Power supply and battery calculations.
   10. A letter from the manufacturer stating that the fire alarm system contractor is authorized to sell, service and install the submitted equipment.

B. Submittal shall include documentation confirming all qualifications in 1.04-A have been met. Submittals without qualification documentation shall be rejected.
C. All submittal data will be in bound form with contractor’s name, supplier’s name, project name, and state fire alarm license number adequately identified.
D. Only basic equipment devices have been shown on the contract drawings. Specific wiring between equipment/devices has not been shown. It is the contractor’s responsibility to submit for approval the COMPLETE ENGINEERED system configuration and layout showing all devices, wiring, conduit, and locations along with other required information as specified herein.

1.06 COORDINATION
A. It shall be the responsibility of the installing contractor to coordinate all requirements surrounding installation of the fire alarm system with all trades including, but not exclusive of: electrical contractor, sprinkler contractor, and HVAC/controls contractor and intercom system. Adequate coordination shall be provided to insure proper installation and interface to all peripheral items required to interact with the fire alarm and communication system to provide a complete and functional life safety system.
PART 2 - PRODUCTS

2.01 SYSTEM FUNCTIONAL OPERATION

A. Alarm Detection
   1. When a fire alarm condition is detected by any of the system alarm initiating devices, the following functions shall occur:
      a. The system common alarm LED on the CPU Module shall flash. The internal audible trouble device shall sound. Acknowledgement or silencing the alarm condition shall silence the alarm signals and cause flashing alarm LED’s to illuminate steady.
      b. An 80 character back-lit LCD display shall indicate all applicable information associated with the alarm condition including: zone, device type, divide location, and time of alert. Location and zoning messages shall be custom field programmed to respective premises.
      c. Any remote or local annunciator LED’s associated with the alarm zone shall be illuminated as herein specified.
      d. A three-channel digital alarm communicator shall be integrally provided and transmit trouble and alarm signals to an approved remote station (remote station connection and service provided by Owner).
      e. All automatic events programmed to the alarm point shall be executed and the associated indicating devices and/or outputs activated.
      f. Activate all audible and visual alarm notification devices.
      g. De-activate HVAC systems over 2,000 CFM.
      h. Display system status changes on the remote annunciators.
      i. Release all smoke doors, fire doors, fire coiling doors, fire smoke dampers and fire shutters.

B. System Trouble Detection
   1. When a trouble condition is detected by the CPU, one of the system initiating, alarm or SLC circuits, the following functions shall immediately occur:
      a. The system trouble LED on the CPU module shall flash and the internal audible trouble device shall sound. Acknowledgement of the trouble condition shall silence the audible trouble device and cause all trouble LED’s to illuminate steady.
      b. The 80-character alphanumeric LCD annunciator shall display all applicable information via the alphanumeric display associated with the respective trouble condition and its location.

C. Auxiliary Control
   1. All designated "non-silenceable" auxiliary control functions shall remain in operation (even upon silencing of audible alarms) until such time as the control panel is cleared and reset manually (i.e. fan control outputs, central station interface, elevator recall interface, etc.).
   2. Activation of duct smoke detectors associated fans shall shutdown their respective units immediately in addition to identifying the condition as herein specified. Duct detectors shall be programmed as a supervisory condition per NFPA 72.

D. System Supervisory Detection
   1. When a supervisory condition is detected by the fire alarm control panel, the following functions shall occur:
      a. The fire alarm control panel supervisory indicator shall flash and the internal audible device shall sound. Acknowledgment of the supervisory condition shall silence the audible device and cause the supervisory indicator to illuminate steady.
      b. The 80-character liquid crystal display shall display all applicable information associated with the respective supervisory condition.
      c. Activate a supervisory contact closure to interface with the owner provided central station monitoring service.
      d. Print the status change messages on the system printer.
      e. Display the system status change on the remote annunciators.

E. Fire Drill Control
1. Provide a fire drill switch located on the Fire Alarm Control Panel. When activated, this switch will activate all horn/strobes and speakers for a fire drill. It shall not release fire shutter, shut down air handling equipment or recall elevators. If a fire alarm condition is detected, the system shall operate as defined in part 2.01A of this section.

2.02 ZONING
A. The system shall have the inherent capability to employ "Intelligent" smoke detectors and addressable interface devices capable of being recognized and annunciated at the main control panel on an individual basis. All zoning/device location information shall be totally field programmable to exact job requirements as approved by the Architect/Engineer.

2.03 FIRE ALARM CONTROL PANEL
A. The fire alarm control panel shall be Notifier series NFS2-640. The control panel shall utilize DISTRIBUTED solid-state MICROPROCESSORS. The microprocessor based CPU shall be completely FIELD PROGRAMMABLE. CPU module shall provide for programmable non-volatile EEPROM memory. All circuitry shall be U.L. listed for power-limited application. System shall be sized to accommodate the capacity of the system specified and shown on the drawings. System shall be capable of being networked for future expansion.

B. Central Processing Unit Module (CPU)
1. The CPU shall contain and execute all custom time control functions or control-by-event programs for specified events including ‘Holiday’ exceptions. Time control event/programs shall be automatically overridden by priority fire alarm events. All programs shall be held in non-volatile programmable EEPROM memory, and shall be lost if both system primary and secondary power failure occurs.
2. System CPU shall also provide for non-alarm points for non-fire, low priority building functions. The CPU shall provide capability of multi-stage signaling, tornado warning, positive alarm sequencing as well as remote control system operation.

C. Display
1. The DIA shall provide an 80-character backlit, supertwist Liquid Crystal Display (LCD). It shall provide Light-Emitting Diodes (LED’s) for AC POWER; SYSTEM ALARM; SYSTEM TROUBLE; SUPERVISORY; CPU FAIL; and ALARM SILENCED.
2. The display shall provide power to a 21-key membrane keypad with control capability to command all system functions, status readouts, manual control action, and entry of any alphanumeric or numeric information. The keypad shall include means to enter multiple five-digit passwords to prevent unauthorized manual control programming.

D. Control Switches
1. Acknowledge/Step Switch
2. Signal Silence Switch
3. Evacuate
4. Lamp Test/Reset

E. System Outputs
1. The system shall provide the following outputs:
   a. One port for CRT, modem, and/or printer (RS-232c)
   b. One port for supervised remote LCD annunciators (RS-485)
   c. Four notification appliance circuits (NAC) F. Loop Interface (SLC)
   d. The CPU shall communicate and provide power to all devices on its loop over a single pair of wires. The CPU shall receive digital/ANALOG information from all "intelligent" detectors and shall process this information to determine normal, alarm, trouble, and sensitivity conditions. The analog information may be used for automatic test and determination of maintenance requirements, and be U.L. listed for such use. The CPU module shall individually monitor all "intelligent" detectors for sensitivity variation initiating a trouble condition should detector sensitivity "drift" become excessive. The system control unit shall have the capability to remotely read each detector’s sensitivity in % obscuration, and if need be, electronically adjust the detector sensitivity as required for existing conditions within U.L. recommended limits. In addition, the system shall incorporate a "day/night" sensitivity feature. The system shall provide capability to program each individual detector for multiple ‘pre-alarm’ conditions. Each ‘pre-alarm’ level shall be field programmable as a function of the programmed alarm level. The
system shall allow designated control-by-event actions to occur as may be required prior to any sensor reaching the designated alarm point.

F. Non-Lock Walk Test
   1. The system shall include a special non-lock "walk test" mode. The walk test mode shall incorporate a one-hour time-out feature to return system to normal. Test results shall be capable of being generated and displayed on LCD annunciator or printed out on system printer.

G. Automatic Detector Test
   1. The system shall include a special automatic detector test feature, which permits reading and adjustment of the sensitivity of all intelligent detectors from the main control panel. In addition, the automatic test feature shall also permit the functional testing of any "intelligent" detector or addressable interface device individually from the main control panel. An automatic detector test shall occur automatically a minimum of every two-hour period or be initiated manually from the FACP as desired. Automatic detector test sequencing shall be terminated upon receipt of a true alarm condition.

H. Special System Reports
   1. The system shall have the ability to generate and print, upon command, system and point status reports. Selection of 'system' read status provides the operator with global system programming information as well as providing the operator with all individual point programming data. The system shall also provide the capability to print out a detailed 'history' report from system history file upon command.

I. Field Programming
   1. The system shall be 100% field programmable without the need for external computers or, PROM programmers, and shall NOT require replacement of memory IC’s. All programs shall be stored in non-volatile EEPROM memory. Programming shall be accomplished only after entering an appropriate and pre-selected five-digit password security code. System programming mode shall NOT require the system to be taken off-line nor prohibit the system from performing its normal operations and routines. The system shall be capable of revising/changing programmed functions or system expansion at any time subsequent to initialization as described herein without factory modifications or factory programming. Field programming via the use of external computers may be considered provided programming can be accomplished on-site and the owner is permanently furnished with the required programming apparatus and software as part of this contract.

J. Event History
   1. The main fire alarm panel shall have the resident ability to store a minimum of 600 system events in chronological order of occurrence. Event history shall include all system alarms, troubles, operator actions, unverified alarms, circuit/point alterations, and component failures. Events shall be time and date stamped. Events shall be stored in non-volatile buffer memory. Access to history buffer shall be secured via five-digit password security code. Systems not employing event history memory storage shall be required to furnish a printer/recorder for recording system events.

K. Power Supply
   1. The power supply shall provide all control panel and peripheral power needs with filtered power as well as rectified 24VDC power for external audio-visual devices. All power supplies shall be designated to meet UL and NFPA requirements for POWER-LIMITED operation on all external signaling lines, including initiating circuits and indicating circuits.
   2. Input power shall be 120VAC 60Hz. The power supply shall provide internal supervised batteries and automatic charger. The power supply shall provide both positive and negative ground fault supervision, battery/charger fail condition, A.C. power fail indicators. The power supply shall also provide supervision of modular expansion power supplies as may be required.

2.04 FIELD DEVICES
   A. Multi sensor Detector (Smoke and Heat)
      1. Provide Notifier FPTI-951 intelligent multi sensor smoke detectors. The multi sensor analog detector shall use a light scattering type photoelectric smoke sensor, a unipolar
ionization smoke sensor and an ambient temperature sensor to sense changes in air samples from its surroundings. The integral microprocessor shall employ time based algorithms to dynamically examine data. The Multi sensor shall be capable of adapting to ambient environmental conditions. The temperature sensor shall self-adjust to the ambient temperature of the surrounding air and input an alarm when there is a change of 65°F in ambient temperature. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, age and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC. Separately mounted photoelectric detectors, ionization detectors and heat detectors in the same location are not acceptable alternatives.

2. The Multi sensor smoke detector shall be rated for ceiling installation at minimum of 30 ft. (9.1m) centers and suitable for wall mount applications. The Multi sensor shall be suitable for direct insertion into air ducts up to 3 ft. (0.91m) high and 3 ft. (0.91m) wide and air velocities up to 500 ft./min. (0-2.54m/sec) without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The integral heat sensor shall cause an alarm when it senses a change in ambient temperature of 65°F or reaches it fixed temperature alarm set point of 135°F nominal. The Multi sensor detector shall be suitable for operation in the following environment:
   a. Temperature: 32°C to 100°C (0°C to 38°C)
   b. Humidity 0-93% RH, non-condensing
c. Elevation: Up to 6,000 ft. (1828m)

B. Intelligent Duct Detector
   1. Notifier model DNR series duct mounted “intelligent” photoelectric smoke detectors shall be provided per applicable codes. Detectors shall operate on the same principles and exhibit the same basic characteristics as area type “intelligent” smoke sensors. The unit shall be capable of interchanging/accepting either photo-electronic or ionization type sensors. The detector shall operate in air velocities of 300 FPM to 4,000 FPM. Each detector shall interface directly to the system SLC loop without the use of zone modules.
   2. The unit shall consist of a clear noryl molded plastic enclosure with integral conduit knockouts. The unit shall be provided with clear faceplate cover to provide visual viewing of detector/sensor for monitoring sensor operation and chamber condition. The duct housing shall be provided with gasket seals to insure proper seating of the housing to the associated ductwork. Each unit’s sampling tubes shall extend the width of the duct and be provided with porosity filters to reduce sensor/chamber contamination. Detectors shall be installed per NFPA 90A, and be listed with the fire alarm control panel. A remote LED shall be located on the corridor ceiling adjacent to the respective detector where detectors are not plainly visible or concealed from view.

C. Intelligent Thermal Detectors
   1. Notifier Model FST-851R analog, fixed temperature and rate of rise thermal detectors shall be provided where indicated on the drawings. The detectors shall use dual electronic thermostats to measure temperature levels in the chamber and shall, on command from the control panel, send data to the panel representing the analog temperature level.
   2. The detectors shall provide address-setting means on the detector heat using rotary decimal switches. No binary coding shall be required. Systems requiring separate detector programming apparatus will be unacceptable.
   3. The detectors shall provide dual alarm and power/status LED’s. Status LED’s shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel. Both LED’s may be placed into steady illumination by the control panel, indicating that an alarm condition has been detected. An output connection shall also be provided in the base to connect an external remote alarm LED.
   4. The detector shall be semi-flush ceiling mounted and be provided with modular detector head with twist-lock base.
   5. Provide weatherproof heat detectors in the Garage Areas or other non-airconditioned areas where detection is required.
D. Addressable Manual Pull Stations
1. Notifier Model NBG-12LX manual stations shall be provided where indicated on the drawings. The manual station shall provide address-setting means using rotary decimal switches. No binary coding shall be required.
2. Manual stations shall be designed for semi-flush mounting on standard electrical box. The station shall be constructed of hi-impact red molded Lexan with instructions for station operation in raised white letters. Stations shall be of the dual action type.
3. All manual pull stations shall be provided with an STI-1100 series clear plastic cover with integral horn.

E. Monitor Module
1. Notifier model FMM-101 addressable monitor modules shall be provided where required to interface to contact alarm devices. The monitor module shall be used to connect a supervised zone of conventional initiating devices to an intelligent SLC loop.
2. The monitor module shall provide address-setting means using rotary decimal switches. No binary coding shall be required.

F. Control Module
1. Notifier model FCM-1 or FRM-1 control and relay modules shall be provided where required to provide audible alarm interface and/or relay control interface. The control module shall be used to connect a supervised zone of conventional indicating devices to an intelligent loop. The zone may be wired class A or class B - field selected. The control module may be optionally wired as dry contact (form C) relay.
2. The control module shall provide address-setting means using rotary decimal switches. No binary coding shall be required. A status LED shall be provided which shall flash under normal conditions, indicating that the control module is operational and in regular communication with the control panel. The LED shall illuminate steady when the device is actuated via the fire alarm control panel.

G. Electronic Audio Visual Devices
1. Audible/Visual alarm devices shall be Notifier "L" Series electronic horn/strobe units, to be located where indicated on the drawings. Devices shall be wall or ceiling mounted as indicated on the drawings. AV devices shall be provided with the ability to provide multiple candela settings. Units shall operate at 24VDC and be polarized supervised. Each unit shall provide a choice of three different audible tones capable of being field selected. Preferred alarm signal shall be a temporal tone producing a sound pressure level of 84 dBA. The visual device shall use Xenon strobe type producing a minimum of 15 candela on a 24 VDC limited energy supervised circuit and meet the requirements of ADA and TAS. Strobe unit shall automatically flash upon operation of the horn. Horn/strobe unit shall be provided in textured white finish and be flush mounted. All visual devices shall be synchronized.

H. Electronic Alarm Horn
1. Provide Notifier “L” Series solid state electronic alarm device where indicated on the contract drawings. Units shall operate at 24 VDC and be polarized supervised. Each unit shall provide a choice of three different audible tones capable of being field selected. Preferred alarm signal shall be a temporal tone producing a sound pressure level of 84 dBA. Units shall be flush mounted and molded of high-impact white plastic.

I. Exterior Audio-Visual Devices
1. All audiovisual devices located outside or labeled weatherproof shall be weatherproof. Provide the following devices:
   b. SpectrAlert Advance for “SK” Series for visual devices
   c. All devices shall be provided with a weather proof type back box.

J. High Intensity Visual Signals
1. Provide a Notifier “L” Series visual signal device. High intensity visual signals shall be installed where shown on the drawings and as may be required by the Americans with Disabilities Act (Public Law 101-336) and TAS.
2. High intensity visual alarms shall be Xenon strobe type producing a minimum of 15 candela on a 24 VDC limited energy supervised circuit. Alarm devices shall be designated to be wall or ceiling mounted as indicated on the drawings. Signals shall operate in unison with audible alarm appliances. All visual devices shall be
synchronized. Units shall be flush mounted and shall be provided in textured white.

K. Auxiliary AHU Relays
1. Notifier/Air Products model MR-101/C relays or approved equal shall be provided for HVAC and AHU control and interface. Relays shall be heavy duty type and rated up to 10 amps at 24 VDC, 60 HZ. Relays shall be provided with NEMA I dust cover assembly and be provided with SPDT contacts as well as (fail safe) so that if the cable is broken, disconnected etc., the AHU will automatically shut down.

L. Field Charging Power Supplies
1. Provide Notifier FCPS-24 power supplies with battery backup as required. Provide 120 volts dedicated circuit to each power supply.

M. Remote LCD Alpha-Numeric Annunciators
1. Provide where indicated on the drawings, a Notifier FDU-80 remote LCD alpha-numeric annunciator to annunciate all system events and duplicate the displayed status at the main FACP. The annunciator shall be a backlit eighty-character LCD display and operate via the system RS485 and RS232 serial output terminal from main FACP. The LCD display shall automatically illuminate upon receipt of an alarm or trouble condition. The luminary source shall extinguish during normal/standby model to conserve power. The unit shall operate from FACP 24VDC power and function during system power failure while the system resides on standby batteries. The remote LCD annunciator shall include:
   a. Integral time-date clock
   b. Time-date select clock
   c. Time-date/contrast adjust
   d. Display/step switch
   e. System reset
   f. System silence
   g. System acknowledge
   h. Integral trouble buzzer
2. Annunciator shall upon command display the first system alarm, last alarm, and system alarm count. The unit shall be equipped with an integral lamp test feature. The unit shall be semi flush mounted where shown.

N. Protective Covers
1. Provide protective covers on all wall mounted fire alarm devices located in student restrooms, corridors and in the cafeteria. These protective covers shall be manufactured by Safety Technology International, Inc. (STI). These covers shall be provided on all devices including but not limited to smoke detectors, heat detectors, audible and visual devices, pull stations, etc. The mounting of a device shall be reinforced to enable the protective covers to protect the fire alarm devices.

PART 3 - EXECUTION
3.01 DESIGN CRITERIA
A. The contractor shall provide drawings for Owner, Engineer and Fire Marshall’s approval.
B. Drawings shall be prepared by a state licensed alarm planning superintendent.
C. Drawings shall comply with all local, state and federal code. These include but not limited to N.E.C., U.L., NFPA, etc.
D. Locate the fire alarm control panel in the day room unless otherwise directed by Owner.
E. Locate a remote annunciator in the Fire Command Room.
F. Additional items required above minimum codes include the following:
   1. Pull Stations – All exits including exit stair wells on multi story buildings and at the FACP.
   2. Smoke Detectors – Paths of egress, electrical rooms, mechanical rooms, MDF, IDF, storage rooms, top of stairs, elevator machine room, top of elevator shaft, above each fire alarm panel and remote power supplies terminal cabinets.
   3. Duct type smoke detectors – all air handling units over 2000 CFM in duct work or return air paths.
5. Flow switches – Sprinkler riser.
6. Horn - throughout the building.
7. Strobes – throughout the building.
8. Remote Power supplies: Locate in mechanical rooms, electrical rooms, MDF or other areas approved by Owner.
9. Smoke Detectors with low frequency sounder bases in all sleeping rooms.

3.02 INSTALLATION

A. Wiring:
1. All wiring shall be in accordance with NFPA 72 and the National Electrical Code, Local Codes, and article 760 of NFPA Standard 70. All wiring sizes shall conform to recommendations of the equipment manufacturer, and as indicated on the engineered shop drawings.
2. All wire shall be U.L. Listed, limited energy (300 volt) FPLP or MPP wire and shall be run open in return air ceiling plenums. The wire shall be listed to U.L. TEST 910 for such applications and is of the low smoke producing fluorocarbon type and complies with NEC Article 760 if so approved by the local authority having jurisdiction. Provide conduit in all inaccessible locations, inside concealed wall, all mechanical/electrical rooms, or other areas where wiring might be exposed and subject to damage.
3. Support wire clear of knock out panels, access panels, and maintenance spaces for equipment. Wire and cable shall be run using wire management techniques supporting cable as close as possible to within one foot of the floor or roof rafters. Wire supports shall be directly fastened to the structure on a maximum of five-foot centers. Wire routing shall be parallel and perpendicular to building lines. The wire and cable shall be secured with tie wraps or carrier wire. Sagging more than three inches will not be allowed nor will bending of the supporting ring structure.
4. All wiring for SLC signaling circuits shall be of the twisted low capacitance type to guard against outside RF and EMF interference and induced noise.
5. All wiring shall be run in a supervised fashion (i.e. no branch wiring or dog-legged wiring) per NFPA requirements such that any wiring disarrangement will initiate the appropriate trouble signals via the main control panel per NFPA and U.L. requirements.
6. Wiring splices shall be kept to a minimum with required splices to be made in designated terminal boxes or at field device junction boxes. Transposing or color code changes of wiring will not be permitted. End-of-line supervisory devices shall be installed with the last device on the respective circuit. Said device shall be appropriately marked designating it as the terminating device on the respective circuit.
7. C wiring or any other wiring shall be run in the same conduit as fire alarm wiring

B. Conduit/Raceway
1. All wire shall be installed in an approved conduit/raceway system (except where permitted by NEC and the local authority having jurisdiction). Maximum conduit "fill" shall not exceed 40% per NEC.
2. Conduit and raceway system shall be installed as specified under the general electrical section of the specifications, and per NEC.
3. Minimum conduit size shall be 3/4" EMT. Install conduit per engineered shop drawings.

C. Minimum Wire Sizes Shall Be as Follows:
1. Signaling Line Circuit: 18 AWG
2. Notification Appliance Circuit: 14 AWG
3. Relay Control Circuits: 18 AWG

D. Sprinkler Valves
1. Contractor shall connect all tamper switches and post indicator valves to the supervisory circuit. Connect all water flow switches to the alarm circuit. Coordinate exact locations of water vaults valves and flow switches with sprinkler contractor.

3.03 NOTIFICATION APPLIANCE CIRCUITS SYNCHRONIZATION

A. All visual and audible devices shall be synchronized per the current state adopted version of NFPA 72. Provide all components required.
3.04 TEST AND REPORTS
A. A state licensed factory trained technical representative of the manufacturer shall perform the final control panel connections and supervise testing of the system and it shall be subject to the approval of the responsible engineer and owner. Upon completion of the acceptance tests, the owner and/or his representatives shall be instructed in the proper operation of the system.
B. The installing contractor shall functionally test each and every device in the entire system for proper operation and response. In addition, each circuit in the system shall be fully tested for wiring supervision to insure proper wiring installation. Any items found not properly installed or non-functioning shall be replaced or repaired and re-tested. All testing shall be supervised by a licensed fire alarm superintendent.
C. The installing contractor shall provide a complete written report on the functional test of the entire system. The test and report shall verify the function of each device in the system, operation of all auxiliary control functions, and the proper operation of the main fire alarm control panel. A copy of the test report shall be provided with maintenance manuals. The test report shall be signed and dated by the licensed fire alarm superintendent responsible for supervising the final system test and checkout.
D. The installing contractor’s fire alarm superintendent shall test the entire system in the presence of the local authorities having jurisdiction.

3.05 SPARE DEVICES
A. Provide 5% spare field devices including labor to install them. Devices not used shall be given to the Owner at completion of the job.

3.06 WARRANTY
A. The fire alarm system shall be free from defects in workmanship and materials, under normal use and service, for a period of one year from the date of acceptance or beneficial occupancy, whichever shall occur first. Any equipment shown to be defective shall be repaired, replaced or adjusted during normal working hours at no cost to the owner.

3.07 GRAPHIC FLOOR PLANS
A. Provide 1/16" = 1'-0" floor plan showing all devices and zoning. Zoning shall correspond to the zone on the fire alarm control panel. The floor plans shall be framed with a glass cover and located by the fire alarm control panel. This graphic floor plan shall use the actual room numbers based on the architectural graphics package. Verify specific requirements with Owner. Provide a sample for approval.

END OF SECTION