

**PROJECT MANUAL
100% CONSTRUCTION
DOCUMENTS**

**Orange County Bithlo Community Center HVAC
Y17-902C**

SGM Engineering, Inc.
935 Lake Baldwin Lane
Orlando, FL 32814

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SECTION 01 10 00 - SUMMARY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Work covered by the Contract Documents.
 - 2. Use of premises.
 - 3. Owner's occupancy requirements.
 - 4. Work restrictions.
 - 5. Specification formats and conventions.
- B. Related Sections include the following:
 - 1. Division 01 Section "Temporary Facilities and Controls" for limitations and procedures governing temporary use of Owner's facilities.

1.3 WORK COVERED BY CONTRACT DOCUMENTS

- A. The Work consists of the following:
 - 1. The Work includes replacing the existing rooftop chiller and all associated pumps, controls, drives, electrical, etc. This is a brief description of the work and is not all inclusive. This scope is complimented by the set of construction drawings and specifications.

1.4 TYPE OF CONTRACT

- A. Project will be constructed under lump sum contract.

1.5 USE OF PREMISES

- A. General: Contractor shall have limited use of premises for construction operations as indicated on Drawings by the Contract limits.
- B. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.
 - 1. Owner Occupancy: Allow for Owner occupancy of Project site and use by the public.
 - 2. Driveways and Entrances: Keep driveways, parking areas, loading areas, and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.

- a. Schedule deliveries to minimize use of driveways and entrances.
 - b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- C. Use of Existing Building: Maintain existing building in a weathertight condition throughout construction period. Repair damage caused by construction operations. Protect building and its occupants during construction period.

1.6 OWNER'S OCCUPANCY REQUIREMENTS

- A. Full Owner Occupancy: Owner will occupy site and existing building during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits, unless otherwise indicated.
- 1. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and authorities having jurisdiction.
 - 2. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

1.7 WORK RESTRICTIONS

- A. On-Site Work Hours: Work shall be generally performed inside the existing building during normal business working hours of 7 a.m. to 5 p.m., Monday through Friday, except otherwise indicated.
- 1. Weekend Hours: To be coordinated with Owner as needed to keep from obstructing Owners occupancy during change out of equipment or any outage requirements.
 - 2. Hours for Utility Shutdowns: to be coordinated with Owners Representative with a minimum of 72 hours required for shut down.
- B. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
- 1. Notify Owner not less than 3 days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner's written permission.

1.8 SPECIFICATION FORMATS AND CONVENTIONS

- A. Specification Format: The Specifications are organized into Divisions and Sections using the 50-division format and CSI/CSC's "MasterFormat" numbering system.
- 1. Section Identification: The Specifications use Section numbers and titles to help cross-referencing in the Contract Documents. Sections in the Project Manual are in numeric sequence; however, the sequence is incomplete because all available Section numbers are not used. Consult the table of contents at the beginning of the Project Manual to determine numbers and names of Sections in the Contract Documents.
 - 2. Division 01: Sections in Division 01 govern the execution of the Work of all Sections in the Specifications.

- B. Specification Content: The Specifications use certain conventions for the style of language and the intended meaning of certain terms, words, and phrases when used in particular situations. These conventions are as follows:
1. Abbreviated Language: Language used in the Specifications and other Contract Documents is abbreviated. Words and meanings shall be interpreted as appropriate. Words implied, but not stated, shall be inferred as the sense requires. Singular words shall be interpreted as plural, and plural words shall be interpreted as singular where applicable as the context of the Contract Documents indicates.
 2. Imperative mood and streamlined language are generally used in the Specifications. Requirements expressed in the imperative mood are to be performed by Contractor. Occasionally, the indicative or subjunctive mood may be used in the Section Text for clarity to describe responsibilities that must be fulfilled indirectly by Contractor or by others when so noted.
 - a. The words "shall," "shall be," or "shall comply with," depending on the context, are implied where a colon (:) is used within a sentence or phrase.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 10 00

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SECTION 010270 - APPLICATION FOR PAYMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section specifies administrative and procedural requirements governing the Contractor's Applications for Payment.
 - 1. Coordinate the Schedule of Values and Applications for Payment with the Contractor's Construction Schedule, Submittal Schedule, and List of Subcontracts.

1.3 SCHEDULE OF VALUES

- A. Coordination: Coordinate preparation of the Schedule of Values with preparation of the Contractor's Construction Schedule.
 - 1. Correlate line items in the Schedule of Values with other required administrative schedules and forms, including:
 - a. Contractor's Construction Schedule.
 - b. Application for Payment forms, including Continuation Sheets.
 - c. List of subcontractors.
 - d. Schedule of allowances.
 - e. Schedule of alternates.
 - f. List of products.
 - g. List of principal suppliers and fabricators.
 - h. Schedule of submittals.
 - 2. Submit the Schedule of Values to the County's designated Representative and Architect at the Pre-Construction meeting.
- B. Format and Content: Use the County form
 - 1. Identification: Include the following Project identification on the Schedule of Values:
 - a. Project name and location.
 - b. Name of the Architect.
 - c. Project number.

- d. Contractor's name and address.
 - e. Date of submittal.
 - f. Change Orders shall be added as they are approved.
2. Percentage of Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent.
 3. Provide a breakdown of the Contract Sum in sufficient detail to facilitate continued evaluation of Applications for Payment and progress reports. Coordinate with the Project Manual table of contents. Break principal subcontract amounts down into several line items.
 4. Provide a separate line item in the Schedule of Values for each part of the Work where Applications for Payment may include materials or equipment, purchased or fabricated and stored, but not yet installed.
 - a. Materials shall be stored on-site only to be included in the Application for Payment.
 5. Provide separate line items on the Schedule of Values for initial cost of the materials, for each subsequent stage of completion, and for total installed value of that part of the Work.
 6. Margins of Cost: Show line items for indirect costs and margins on actual costs only when such items are listed individually in Applications for Payment. Each item in the Schedule of Values and Applications for Payment shall be complete. Include the total cost and proportionate share of general overhead and profit margin for each item.
 - a. Temporary facilities and other major cost items that are not direct cost of actual work-in-place may be shown either as separate line items in the Schedule of Values or distributed as general overhead expense, at the Contractor's option.

1.4 APPLICATIONS FOR PAYMENT

- A. Each Application for Payment shall be consistent with previous applications and payments as certified by the Architect and paid for by the Owner.
 1. The initial Application for Payment, the Application for Payment at time of Substantial Completion, and the final Application for Payment involve additional requirements.
- B. Payment-Application Times: Each progress-payment date is indicated in the Agreement. The period of construction Work covered by each Application for Payment is the period indicated in the Agreement.
- C. Payment-Application Forms: Use County form for Applications for Payment.

- D. Application Preparation: Complete every entry on the form. Include notarization and execution by a person authorized to sign legal documents on behalf of the Contractor. The Architect will return incomplete applications without action.
1. Entries shall match data on the Schedule of Values and the Contractor's Construction Schedule.
 2. Change Orders amounts may only be shown on the Application for Payment when they are fully executed and approved by the County.
- E. A field review shall be made by the Owner, Architect and the General Contractor one week before Final copies are transmitted to the Architect for his recommendation to the Owner. The Application for Payment shall only include work completed and materials used or stored on site as of the time and date of the field review.
- F. Transmittal: Submit 5 signed and notarized original copies of each Application for Payment.
- G. Application for Payment at Substantial Completion: Following issuance of the Certificate of Substantial Completion, submit an Application for Payment.
1. Administrative actions and submittals that shall precede or coincide with this application include:
 - a. Occupancy permits and similar approvals.
 - b. Test/adjust/balance records.
 - c. Equipment demonstrations.
 - d. Final cleaning.
 - e. Keys.
- H. Final Payment Application: Administrative actions and submittals that must precede or coincide with submittal of the final Application for Payment include the following:
1. Completion of Project closeout requirements.
 2. Completion of items specified for completion after Substantial Completion.
 3. Ensure that unsettled claims will be settled.
 4. Ensure that incomplete Work is not accepted and will be completed without undue delay.
 5. Transmittal of required Project construction records to the Owner.
 6. Removal of temporary facilities and services.
 7. Removal of surplus materials, rubbish, and similar elements.
 8. Warranties (guarantees) and maintenance agreements.
 9. Maintenance instructions.
 10. Meter readings.
 11. Contractor's release of lien (on County form)
 12. Sub-Contractor's and supplier's release of lien
 13. Consent of Surety (dated and notarized)
 14. Power-of-Attorney (dated and notarized)

15. Asbestos-Free statement on Contractor's letterhead (dated and notarized)

PART 2 - PRODUCTS - (Not Applicable)

PART 3 - EXECUTION - (Not Applicable)

END OF SECTION

SECTION 010350 - MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section specifies administrative and procedural requirements for handling and processing contract modifications.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 013000 "Submittals" for requirements for the Contractor's Construction Schedule.
 - 2. Section 010270 "Applications for Payment" for administrative procedures governing Applications for Payment.
 - 3. Section 016310 "Substitutions" for administrative procedures for handling requests for substitutions made after award of the Contract.

1.3 MINOR CHANGES IN THE WORK

- A. The Architect will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or Contract Time, on Architect's standard Supplemental Instructions form.

1.4 CHANGE ORDER PROPOSAL REQUESTS

- A. Owner-Initiated Proposal Requests: The Architect will issue a detailed description of proposed changes in the Work that will require adjustment to the Contract Sum or Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications.
 - 1. Proposal requests issued by the Architect are for information only. Do not consider them as an instruction either to stop work in progress or to execute the proposed change.
 - 2. Within 14 days of receipt of a proposal request, submit an estimate of cost necessary to execute the change to the Architect for the Owner's review.
 - a. Include a list of quantities of products required and unit costs, with the total amount of purchases to be made. Where requested, furnish survey data to substantiate quantities.
 - b. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.

- c. Include a statement indicating the effect the proposed change in the Work will have on the Contract Time.
- B. Contractor-Initiated Proposals: When latent or unforeseen conditions require modifications to the Contract, the Contractor may propose changes by submitting a request for a change to the Architect.
1. Include a statement outlining the reasons for the change and the effect of the change on the Work. Provide a complete description of the proposed change. Indicate the effect of the proposed change on the Contract Sum and Contract Time.
 2. Include a list of quantities of products required and unit costs, with the total amount of purchases to be made. Where requested, furnish survey data to substantiate quantities.
 3. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
 4. Comply with requirements in Section "Product Substitutions" if the proposed change requires substitution of one product or system for a product or system specified.
 5. Contractor-initiated proposals shall be submitted within 15 days of the event causing the change.
- C. Proposal Request Form: Use forms which will be provided by the Architect. Sample copies are included at the end of this Section.

1.6 CONSTRUCTION CHANGE DIRECTIVE

- A. Construction Change Directive: When the Owner and the Contractor disagree on the terms of a Proposal Request, the Architect may issue a Construction Change Directive. The Construction Change Directive instructs the Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order.
1. The Construction Change Directive contains a complete description of the change in the Work. It also designates the method to be followed to determine change in the Contract Sum or Contract Time.
- B. Documentation: Maintain detailed records on a time and material basis of work required by the Construction Change Directive.
1. After completion of the change, submit an itemized account and supporting data necessary to substantiate cost and time adjustments to the Contract.

1.7 CHANGE ORDER PROCEDURES

- A. On the County's standard form.

PART 2 - PRODUCTS - (Not Applicable)

PART 3 - EXECUTION - (Not Applicable)

END OF SECTION

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DOCUMENT 011065 - PERMIT APPLICATION

1.1 PERMIT APPLICATION INFORMATION

- A. This Document with its referenced attachments is part of the Procurement and Contracting Requirements for Project. They provide Owner's information for Bidders' convenience and are intended to supplement rather than serve in lieu of the Bidders' own investigations. This Document and its attachments are not part of the Contract Documents.
- B. Permit Application: Complete building permit application and file with authorities having jurisdiction within five days of the date of execution of the Contract.
- C. Permit Application: The building permit for Project has been applied for by Architect. A copy of the Permit Application is available at the building department.

END OF DOCUMENT 011065

SECTION 013100 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes administrative provisions for coordinating construction operations on Project including, but not limited to, the following:

- 1. General coordination procedures.
- 2. Coordination drawings.
- 3. RFIs.
- 4. Digital project management procedures.
- 5. Project meetings.

- B. Each contractor shall participate in coordination requirements. Certain areas of responsibility are assigned to a specific contractor.

- C. Related Requirements:

- 1. Section 011200 "Multiple Contract Summary" for a description of the division of work among separate contracts and responsibility for coordination activities not in this Section.
- 2. Section 013200 "Construction Progress Documentation" for preparing and submitting Contractor's construction schedule.
- 3. Section 017300 "Execution" for procedures for coordinating general installation and field-engineering services, including establishment of benchmarks and control points.
- 4. Section 017700 "Closeout Procedures" for coordinating closeout of the Contract.
- 5. Section 019113 "General Commissioning Requirements" for coordinating the Work with Owner's Commissioning Authority.

1.3 DEFINITIONS

- A. BIM: Building Information Modeling.
- B. RFI: Request for Information. Request from Owner, Contractor, Architect, or Contractor seeking information required by or clarifications of the Contract Documents.

1.4 INFORMATIONAL SUBMITTALS

- A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:
 - 1. Name, address, telephone number, and email address of entity performing subcontract or supplying products.
 - 2. Number and title of related Specification Section(s) covered by subcontract.
 - 3. Drawing number and detail references, as appropriate, covered by subcontract.

- B. Key Personnel Names: Within 15 days of starting construction operations, submit a list of key personnel assignments, including superintendent and other personnel in attendance at Project site. Identify individuals and their duties and responsibilities; list addresses and cellular telephone numbers and e-mail addresses. Provide names, addresses, and telephone numbers of individuals assigned as alternates in the absence of individuals assigned to Project.
 - 1. Post copies of list in project meeting room, in temporary field office, and in prominent location in each built facility. Keep list current at all times.

1.5 GENERAL COORDINATION PROCEDURES

- A. Coordination: Coordinate construction operations included in different Sections of the Specifications to ensure efficient and orderly installation of each part of the Work. Coordinate construction operations included in different Sections that depend on each other for proper installation, connection, and operation.
 - 1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
 - 2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
 - 3. Make adequate provisions to accommodate items scheduled for later installation.

- B. Coordination: Each contractor shall cooperate with Project coordinator who shall coordinate its construction operations with those of other contractors and entities to ensure efficient and orderly installation of each part of the Work. Each contractor shall coordinate its own operations with operations included in different Sections that depend on each other for proper installation, connection, and operation.
 - 1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
 - 2. Coordinate installation of different components with other contractors to ensure maximum performance and accessibility for required maintenance, service, and repair.
 - 3. Make adequate provisions to accommodate items scheduled for later installation.

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

1. Prepare similar memoranda for Owner and separate contractors if coordination of their Work is required.
- D. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities and scheduled activities of other contractors to avoid conflicts and to ensure orderly progress of the Work. Such administrative activities include, but are not limited to, the following:
1. Preparation of Contractor's construction schedule.
 2. Preparation of the schedule of values.
 3. Installation and removal of temporary facilities and controls.
 4. Delivery and processing of submittals.
 5. Progress meetings.
 6. Preinstallation conferences.
 7. Project closeout activities.
 8. Startup and adjustment of systems.

1.6 COORDINATION DRAWINGS

- A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely indicated on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.
1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:
 - a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.
 - b. Coordinate the addition of trade-specific information to coordination drawings by multiple contractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.
 - c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
 - d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
 - e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.
 - f. Indicate required installation sequences.
 - g. Indicate dimensions shown on Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternative sketches to Architect indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
- B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical Work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings where required to adequately represent the Work.
 2. Plenum Space: Indicate subframing for support of ceiling, raised access floor, and wall systems, mechanical and electrical equipment, and related Work. Locate components within plenums to accommodate layout of light fixtures and other components indicated on Drawings. Indicate areas of conflict between light fixtures and other components.
 3. Mechanical Rooms: Provide coordination drawings for mechanical rooms showing plans and elevations of mechanical, plumbing, fire-protection, fire-alarm, and electrical equipment.
 4. Structural Penetrations: Indicate penetrations and openings required for all disciplines.
 5. Slab Edge and Embedded Items: Indicate slab edge locations and sizes and locations of embedded items for metal fabrications, sleeves, anchor bolts, bearing plates, angles, door floor closers, slab depressions for floor finishes, curbs and housekeeping pads, and similar items.
 6. Mechanical and Plumbing Work: Show the following:
 - a. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
 - b. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.
 - c. Fire-rated enclosures around ductwork.
 7. Electrical Work: Show the following:
 - a. Runs of vertical and horizontal conduit 1-1/4 inches (32 mm) in diameter and larger.
 - b. Light fixture, exit light, emergency battery pack, smoke detector, and other fire-alarm locations.
 - c. Panel board, switch board, switchgear, transformer, busway, generator, and motor-control center locations.
 - d. Location of pull boxes and junction boxes, dimensioned from column center lines.
 8. Fire-Protection System: Show the following:
 - a. Locations of standpipes, mains piping, branch lines, pipe drops, and sprinkler heads.
 9. Review: Architect will review coordination drawings to confirm that in general the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Architect determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Architect will so inform Contractor, who shall make suitable modifications and resubmit.
 10. Coordination Drawing Prints: Prepare coordination drawing prints according to requirements in Section 013300 "Submittal Procedures."
- C. Coordination Digital Data Files: Prepare coordination digital data files according to the following requirements:

1. File Preparation Format: Same digital data software program, version, and operating system as original Drawings.
2. File Preparation Format: DWG, Version Current, operating in Microsoft Windows operating system.
3. File Submittal Format: Submit or post coordination drawing files using PDF format.

4. Architect will furnish Contractor one set of digital data files of Drawings for use in preparing coordination digital data files.
 - a. Architect makes no representations as to the accuracy or completeness of digital data files as they relate to Drawings.
 - b. Digital Data Software Program: Drawings are available in AutoCAD/Revit.
 - c. Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to Owner and Architect.

1.7 REQUEST FOR INFORMATION (RFI)

- A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.
 1. Architect will return without response those RFIs submitted to Architect by other entities controlled by Contractor.
 2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

- B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
 1. Project name.
 2. Project number.
 3. Date.
 4. Name of Contractor.
 5. Name of Architect.
 6. RFI number, numbered sequentially.
 7. RFI subject.
 8. Specification Section number and title and related paragraphs, as appropriate.
 9. Drawing number and detail references, as appropriate.
 10. Field dimensions and conditions, as appropriate.
 11. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
 12. Contractor's signature.
 13. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
 - a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

- C. RFI Forms: Software-generated form with substantially the same content as indicated above, acceptable to Architect.
1. Attachments shall be electronic files in PDF format.
- D. Architect's and Construction Manager's Action: Architect and Construction Manager will review each RFI, determine action required, and respond. Allow seven Insert number working days for Architect's response for each RFI. RFIs received by Architect or Construction Manager after 1:00 p.m. will be considered as received the following working day.
1. The following Contractor-generated RFIs will be returned without action:
 - a. Requests for approval of submittals.
 - b. Requests for approval of substitutions.
 - c. Requests for approval of Contractor's means and methods.
 - d. Requests for coordination information already indicated in the Contract Documents.
 - e. Requests for adjustments in the Contract Time or the Contract Sum.
 - f. Requests for interpretation of Architect's actions on submittals.
 - g. Incomplete RFIs or inaccurately prepared RFIs.
 2. Architect's action may include a request for additional information, in which case Architect's time for response will date from time of receipt by Architect or Construction Manager of additional information.
 3. Architect's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."
 - a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect and Construction Manager in writing within 10 days of receipt of the RFI response.
- E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly.
1. Project name.
 2. Name and address of Contractor.
 3. Name and address of Architect and Construction Manager.
 4. RFI number including RFIs that were returned without action or withdrawn.
 5. RFI description.
 6. Date the RFI was submitted.
 7. Date Architect's and Construction Manager's response was received.
 8. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
 9. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.
- F. On receipt of Architect's and Construction Manager's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Architect and Construction Manager within seven days if Contractor disagrees with response.

1.8 DIGITAL PROJECT MANAGEMENT PROCEDURES

- A. Architect's Data Files Not Available: Architect will not provide Architect's CAD drawing digital data files for Contractor's use during construction.
- B. Use of Architect's Digital Data Files: Digital data files of Architect's CAD drawings will be provided by Architect for Contractor's use during construction.
 - 1. Digital data files may be used by Contractor in preparing coordination drawings, Shop Drawings, and Project record Drawings.
 - 2. Architect makes no representations as to the accuracy or completeness of digital data files as they relate to Contract Drawings.
 - 3. Digital Drawing Software Program: Contract Drawings are available in AutCAD/Revit.
 - 4. Contractor shall execute a data licensing agreement in the form of Agreement form acceptable to Owner and Architect.
 - a. Subcontractors, and other parties granted access by Contractor to Architect's digital data files shall execute a data licensing agreement in the form of Agreement acceptable to Owner and Architect.
 - 5. The following digital data files will be furnished for each appropriate discipline:
 - a. Floor plans.
 - b. Reflected ceiling plans.
- C. Web-Based Project Software: Use Owner's web-based Project software site for purposes of hosting and managing Project communication and documentation until Final Completion.
 - 1. Web-based Project software site includes, at a minimum, the following features:
 - a. Compilation of Project data, including Contractor, subcontractors, Architect, architect's consultants, Owner, and other entities involved in Project. Include names of individuals and contact information.
 - b. Access control for each entity for each workflow process, to determine entity's digital rights to create, modify, view, and print documents.
 - c. Document workflow planning, allowing customization of workflow between project entities.
 - d. Creation, logging, tracking, and notification for Project communications required in other Specification Sections, including, but not limited to, RFIs, submittals, Minor Changes in the Work, Construction Change Directives, and Change Orders.
 - e. Track status of each Project communication in real time, and log time and date when responses are provided.
 - f. Procedures for handling PDFs or similar file formats, allowing markups by each entity. Provide security features to lock markups against changes once submitted.
 - g. Processing and tracking of payment applications.
 - h. Processing and tracking of contract modifications.
 - i. Creating and distributing meeting minutes.
 - j. Document management for Drawings, Specifications, and coordination drawings, including revision control.
 - k. Management of construction progress photographs.

1. Mobile device compatibility, including smartphones and tablets.
 2. Provide up to seven web-based Project software user licenses for use of Owner, Owner's Commissioning Authority, Construction Manager, Architect, and Architect's consultants. Provide eight hours of software training at Architect's office for web-based Project software users.
 3. At completion of Project, provide digital archive in format that is readable by common desktop software applications in format acceptable to Architect. Provide data in locked format to prevent further changes.
 4. Provide one of the following web-based Project software packages under their current published licensing agreements:
 - a. Autodesk;
 - b. Corecon Technologies, Inc.
 - c. Meridian Systems; Prolog.
 - d. Newforma, Inc.
 - e. Procore Technologies, Inc.
 - f. Viewpoint, Inc.; Viewpoint for Project Collaboration.
- D. PDF Document Preparation: Where PDFs are required to be submitted to Architect, prepare as follows:
1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
 2. Name file with submittal number or other unique identifier, including revision identifier.
 3. Certifications: Where digitally submitted certificates and certifications are required, provide a digital signature with digital certificate on where indicated.

1.9 PROJECT MEETINGS

- A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.
1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Architect of scheduled meeting dates and times a minimum of 10 working days prior to meeting.
 2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
 3. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner, Construction Manager, and Architect, within three days of the meeting.
- B. Preconstruction Conference: Schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Architect, but no later than 15 days after execution of the Agreement.
1. Attendees: Authorized representatives of Owner, Owner's Commissioning Authority, , Construction Manager, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend

the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.

2. Agenda: Discuss items of significance that could affect progress, including the following:
 - a. Responsibilities and personnel assignments.
 - b. Tentative construction schedule.
 - c. Phasing.
 - d. Critical work sequencing and long lead items.
 - e. Designation of key personnel and their duties.
 - f. Lines of communications.
 - g. Use of web-based Project software.
 - h. Procedures for processing field decisions and Change Orders.
 - i. Procedures for RFIs.
 - j. Procedures for testing and inspecting.
 - k. Procedures for processing Applications for Payment.
 - l. Distribution of the Contract Documents.
 - m. Submittal procedures.
 - n. Sustainable design requirements.
 - o. Preparation of Record Documents.
 - p. Use of the premises and existing building.
 - q. Work restrictions.
 - r. Working hours.
 - s. Owner's occupancy requirements.
 - t. Responsibility for temporary facilities and controls.
 - u. Procedures for moisture and mold control.
 - v. Procedures for disruptions and shutdowns.
 - w. Construction waste management and recycling.
 - x. Parking availability.
 - y. Office, work, and storage areas.
 - z. Equipment deliveries and priorities.
 - aa. First aid.
 - bb. Security.
 - cc. Progress cleaning.
 3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.
- C. Project Closeout Conference: Schedule and conduct a project closeout conference, at a time convenient to Owner and Architect, but no later than 5 days prior to the scheduled date of Substantial Completion.
1. Conduct the conference to review requirements and responsibilities related to Project closeout.
 2. Attendees: Authorized representatives of Owner, Construction Manager, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the meeting. Participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
 3. Agenda: Discuss items of significance that could affect or delay Project closeout, including the following:
 - a. Preparation of Record Documents.

- b. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
 - c. Procedures for completing and archiving web-based Project software site data files.
 - d. Submittal of written warranties.
 - e. Requirements for completing sustainable design documentation.
 - f. Requirements for preparing operations and maintenance data.
 - g. Requirements for delivery of material samples, attic stock, and spare parts.
 - h. Requirements for demonstration and training.
 - i. Preparation of Contractor's punch list.
 - j. Procedures for processing Applications for Payment at Substantial Completion and for final payment.
 - k. Submittal procedures.
 - l. Coordination of separate contracts.
 - m. Owner's partial occupancy requirements.
 - n. Installation of Owner's furniture, fixtures, and equipment.
 - o. Responsibility for removing temporary facilities and controls.
4. Minutes: Entity conducting meeting will record and distribute meeting minutes.
- D. Progress Meetings: Conduct progress meetings at biweekly intervals.
1. Coordinate dates of meetings with preparation of payment requests.
 2. Attendees: In addition to representatives of Owner, Owner's Commissioning Authority, Construction Manager, and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
 3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.
 - a. Contractor's Construction Schedule: Review progress since the last meeting. Determine whether each activity is on time, ahead of schedule, or behind schedule, in relation to Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
 - 1) Review schedule for next period.
 - b. Review present and future needs of each entity present, including the following:
 - 1) Interface requirements.
 - 2) Sequence of operations.
 - 3) Resolution of BIM component conflicts.
 - 4) Status of submittals.
 - 5) Status of sustainable design documentation.
 - 6) Deliveries.
 - 7) Off-site fabrication.

- 8) Access.
 - 9) Site use.
 - 10) Temporary facilities and controls.
 - 11) Progress cleaning.
 - 12) Quality and work standards.
 - 13) Status of correction of deficient items.
 - 14) Field observations.
 - 15) Status of RFIs.
 - 16) Status of Proposal Requests.
 - 17) Pending changes.
 - 18) Status of Change Orders.
 - 19) Pending claims and disputes.
 - 20) Documentation of information for payment requests.
4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.
- a. Schedule Updating: Revise Contractor's construction schedule after each progress meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with the report of each meeting.
- E. Coordination Meetings: Conduct Project coordination meetings at biweekly intervals. Project coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and preinstallation conferences.
1. Attendees: In addition to representatives of Owner, Owner's Commissioning Authority, Construction Manager, and Architect, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meetings shall be familiar with Project and authorized to conclude matters relating to the Work.
 2. Agenda: Review and correct or approve minutes of the previous coordination meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.
 - a. Combined Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to combined Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
 - b. Schedule Updating: Revise combined Contractor's construction schedule after each coordination meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.
 - c. Review present and future needs of each contractor present, including the following:
 - 1) Interface requirements.
 - 2) Sequence of operations.
 - 3) Resolution of BIM component conflicts.

- 4) Status of submittals.
 - 5) Deliveries.
 - 6) Off-site fabrication.
 - 7) Access.
 - 8) Site use.
 - 9) Temporary facilities and controls.
 - 10) Work hours.
 - 11) Hazards and risks.
 - 12) Progress cleaning.
 - 13) Quality and work standards.
 - 14) Status of RFIs.
 - 15) Proposal Requests.
 - 16) Change Orders.
 - 17) Pending changes.
3. Reporting: Record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011310

SECTION 01 33 00 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for submitting Shop Drawings, Product Data, Samples, and other submittals.
- B. Related Sections include the following:
 - 1. Division 01 Section "Closeout Procedures" for submitting warranties.
 - 2. Division 01 Section "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
 - 3. Division 01 Section "Operation and Maintenance Data" for submitting operation and maintenance manuals.
 - 4. Divisions 02 through 49 Sections for specific requirements for submittals in those Sections.

1.3 DEFINITIONS

- A. Action Submittals: Written and graphic information that requires Owner's responsive action.
- B. Informational Submittals: Written information that does not require Engineer's and Owner's responsive action. Submittals may be rejected for not complying with requirements.

1.4 SUBMITTAL PROCEDURES

- A. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
 - 1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
 - 2. Coordinate transmittal of different types of submittals for related parts of the Work so processing will not be delayed because of need to review submittals concurrently for coordination.
 - a. Owner and Engineer's reserve the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
- B. Submittals Schedule: All submittals shall be received by the Owner within 14 days of notice to proceed. Submittals shall be approved prior to commencement of work.
- C. Processing Time: Allow enough time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineers receipt of submittal. No extension of

the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.

1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. The Owner will advise Contractor when a submittal being processed must be delayed for coordination.
 2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
 3. Resubmittal Review: Allow 15 days for review of each resubmittal.
 4. Sequential Review: Where sequential review of submittals by Architect's consultants, Owner, or other parties is indicated, allow 21 days for initial review of each submittal.
- D. Identification: Place a permanent label or title block on each submittal for identification.
1. Indicate name of firm or entity that prepared each submittal on label or title block.
 2. Provide a space approximately **6 by 8 inches** on label or beside title block to record Contractor's review and approval markings and action taken by Engineer.
 3. Include the following information on label for processing and recording action taken:
 - a. Project name.
 - b. Date.
 - c. Name and address of Engineer.
 - d. Name and address of Contractor.
 - e. Name and address of subcontractor.
 - f. Name and address of supplier.
 - g. Name of manufacturer.
 - h. Submittal number or other unique identifier, including revision identifier.
 - 1) Submittal number shall use Specification Section number followed by a decimal point and then a sequential number (e.g., 06100.01). Resubmittals shall include an alphabetic suffix after another decimal point (e.g., 06100.01.A).
- E. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.
1. Note date and content of previous submittal.
 2. Note date and content of revision in label or title block and clearly indicate extent of revision.
- F. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.

PART 2 - PRODUCTS

2.1 ACTION SUBMITTALS

- A. General: Prepare and submit Action Submittals required by individual Specification Sections.
- B. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.

1. If information must be specially prepared for submittal because standard printed data are not suitable for use, submit as Shop Drawings, not as Product Data.
 2. Mark each copy of each submittal to show which products and options are applicable.
 3. Include the following information, as applicable:
 - a. Manufacturer's written recommendations.
 - b. Manufacturer's product specifications.
 - c. Manufacturer's installation instructions.
 - d. Standard color charts.
 - e. Manufacturer's catalog cuts.
 - f. Wiring diagrams showing factory-installed wiring.
 - g. Printed performance curves.
 - h. Operational range diagrams.
 - i. Mill reports.
 - j. Standard product operation and maintenance manuals.
 - k. Compliance with specified referenced standards.
 - l. Testing by recognized testing agency.
 - m. Application of testing agency labels and seals.
 - n. Notation of coordination requirements.
 4. Submit Product Data before or concurrent with Samples.
 5. Number of Copies: Submit 7 copies of Product Data, unless otherwise indicated. Engineer will return 6 copies. Mark up and retain one returned copy as a Project Record Document.
- C. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data
1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
 - a. Dimensions.
 - b. Identification of products.
 - c. Fabrication and installation drawings.
 - d. Roughing-in and setting diagrams.
 - e. Wiring diagrams showing field-installed wiring, including power, signal, and control wiring.
 - f. Shopwork manufacturing instructions.
 - g. Templates and patterns.
 - h. Schedules.
 - i. Design calculations.
 - j. Compliance with specified standards.
 - k. Notation of coordination requirements.
 - l. Notation of dimensions established by field measurement.
 - m. Relationship to adjoining construction clearly indicated.
 - n. Seal and signature of professional engineer if specified.
 - o. Wiring Diagrams: Differentiate between manufacturer-installed and field-installed wiring.
 2. Sheet Size: Except for templates, patterns, and similar full-size drawings, submit Shop Drawings on sheets at least 8-1/2 by 11 inches but no larger than 30 by 40 inches.

PART 3 - EXECUTION

3.1 CONTRACTOR'S REVIEW

- A. Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer.
- B. Approval Stamp: Stamp each submittal with a uniform, approval stamp.

3.2 ENGINEER'S ACTION

- A. General: Engineer will not review submittals that do not bear Contractor's approval stamp and will return them without action.
- B. Action Submittals: Engineer will review each submittal, make marks to indicate corrections or modifications required, and return it.
- C. Partial submittals are not acceptable, will be considered nonresponsive, and will be returned without review.
- D. Submittals not required by the Contract Documents may not be reviewed and may be discarded.

END OF SECTION 01 33 00

SECTION 01 40 00 - QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for quality assurance and quality control.
- B. Testing and inspecting services are required to verify compliance with requirements specified or indicated. These services do not relieve Contractor of responsibility for compliance with the Contract Document requirements.
 - 1. Specific quality-assurance and -control requirements for individual construction activities are specified in the Sections that specify those activities. Requirements in those Sections may also cover production of standard products.
 - 2. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and -control procedures that facilitate compliance with the Contract Document requirements.
 - 3. Requirements for Contractor to provide quality-assurance and -control services required by Engineer or authorities having jurisdiction are not limited by provisions of this Section.
- C. Related Sections include the following:
 - 1. Division 01 Section "Cutting and Patching" for repair and restoration of construction disturbed by testing and inspecting activities.
 - 2. Divisions 02 through 49 Sections for specific test and inspection requirements.

1.3 DEFINITIONS

- A. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
- B. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Services do not include contract enforcement activities performed by Engineer.
- C. Product Testing: Tests and inspections that are performed by an NRTL, an NVLAP, or a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with industry standards.
- D. Source Quality-Control Testing: Tests and inspections that are performed at the source, i.e., plant, mill, factory, or shop.

- E. Field Quality-Control Testing: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- F. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall mean the same as testing agency.
- G. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, Subcontractor, or Sub-subcontractor, to perform a particular construction operation, including installation, erection, application, and similar operations.
 - 1. Using a term such as "carpentry" does not imply that certain construction activities must be performed by accredited or unionized individuals of a corresponding generic name, such as "carpenter." It also does not imply that requirements specified apply exclusively to tradespeople of the corresponding generic name.

1.4 CONFLICTING REQUIREMENTS

- A. General: If compliance with two or more standards is specified and the standards establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer uncertainties and requirements that are different, but apparently equal, to Architect for a decision before proceeding.
- B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Architect for a decision before proceeding.

1.5 SUBMITTALS

- A. Schedule of Tests and Inspections: Prepare in tabular form and include the following:
 - 1. Specification Section number and title.
 - 2. Description of test and inspection.
 - 3. Identification of applicable standards.
 - 4. Identification of test and inspection methods.
 - 5. Number of tests and inspections required.
 - 6. Time schedule or time span for tests and inspections.
 - 7. Entity responsible for performing tests and inspections.
 - 8. Requirements for obtaining samples.
 - 9. Unique characteristics of each quality-control service.
- B. Reports: Prepare and submit certified written reports that include the following:
 - 1. Date of issue.
 - 2. Project title and number.
 - 3. Name, address, and telephone number of testing agency.
 - 4. Dates and locations of samples and tests or inspections.
 - 5. Names of individuals making tests and inspections.
 - 6. Description of the Work and test and inspection method.
 - 7. Identification of product and Specification Section.
 - 8. Complete test or inspection data.

9. Test and inspection results and an interpretation of test results.
 10. Record of temperature and weather conditions at time of sample taking and testing and inspecting.
 11. Comments or professional opinion on whether tested or inspected Work complies with the Contract Document requirements.
 12. Name and signature of laboratory inspector.
 13. Recommendations on retesting and reinspecting.
- C. Permits, Licenses, and Certificates: For Owner's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

1.6 QUALITY ASSURANCE

- A. General: Qualifications paragraphs in this Article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Installer Qualifications: A firm or individual experienced in installing, erecting, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- C. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or product that are similar to those indicated for this Project in material, design, and extent.
- F. Specialists: Certain sections of the Specifications require that specific construction activities shall be performed by entities who are recognized experts in those operations. Specialists shall satisfy qualification requirements indicated and shall be engaged for the activities indicated.
1. Requirement for specialists shall not supersede building codes and regulations governing the Work.
- G. Testing Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspecting indicated, as documented according to ASTM E 548; and with additional qualifications specified in individual Sections; and where required by authorities having jurisdiction, that is acceptable to authorities.
1. NRTL: A nationally recognized testing laboratory according to 29 CFR 1910.7.
 2. NVLAP: A testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program.
- H. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of

manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

- I. Preconstruction Testing: Where testing agency is indicated to perform preconstruction testing for compliance with specified requirements for performance and test methods, comply with the following:
 1. Contractor responsibilities include the following:
 - a. Provide test specimens representative of proposed products and construction.
 - b. Submit specimens in a timely manner with sufficient time for testing and analyzing results to prevent delaying the Work.
 - c. Provide sizes and configurations of test assemblies, mockups, and laboratory mockups to adequately demonstrate capability of products to comply with performance requirements.
 - d. Build site-assembled test assemblies and mockups using installers who will perform same tasks for Project.
 - e. Build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
 - f. When testing is complete, remove test specimens, assemblies, mockups, and laboratory mockups; do not reuse products on Project.

1.7 QUALITY CONTROL

- A. Owner Responsibilities: Where quality-control services are indicated as Owner's responsibility, Owner will engage a qualified testing agency to perform these services.
 1. Owner will furnish Contractor with names, addresses, and telephone numbers of testing agencies engaged and a description of types of testing and inspecting they are engaged to perform.
 2. Payment for these services will be made from testing and inspecting allowances, as authorized by Change Orders.
 3. Costs for retesting and reinspecting construction that replaces or is necessitated by work that failed to comply with the Contract Documents will be charged to Contractor, and the Contract Sum will be adjusted by Change Order.
- B. Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.
 1. Where services are indicated as Contractor's responsibility, engage a qualified testing agency to perform these quality-control services.
 - a. Contractor shall not employ same entity engaged by Owner, unless agreed to in writing by Owner.
 2. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
 3. Testing and inspecting requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
 4. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

- C. **Manufacturer's Field Services:** Where indicated, engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including service connections. Report results in writing as specified in Division 01 Section "Submittal Procedures."
- D. **Retesting/Reinspecting:** Regardless of whether original tests or inspections were Contractor's responsibility, provide quality-control services, including retesting and reinspecting, for construction that replaced Work that failed to comply with the Contract Documents.
- E. **Testing Agency Responsibilities:** Cooperate with Engineer and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
 - 1. Notify Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
 - 2. Determine the location from which test samples will be taken and in which in-situ tests are conducted.
 - 3. Conduct and interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from requirements.
 - 4. Submit a certified written report, in duplicate, of each test, inspection, and similar quality-control service through Contractor.
 - 5. Do not release, revoke, alter, or increase the Contract Document requirements or approve or accept any portion of the Work.
 - 6. Do not perform any duties of Contractor.
- F. **Associated Services:** Cooperate with agencies performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
 - 1. Access to the Work.
 - 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 - 3. Adequate quantities of representative samples of materials that require testing and inspecting. Assist agency in obtaining samples.
 - 4. Facilities for storage and field curing of test samples.
 - 5. Delivery of samples to testing agencies.
 - 6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
 - 7. Security and protection for samples and for testing and inspecting equipment at Project site.
- G. **Coordination:** Coordinate sequence of activities to accommodate required quality-assurance and -control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.
 - 1. Schedule times for tests, inspections, obtaining samples, and similar activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 REPAIR AND PROTECTION

- A. General: On completion of testing, inspecting, sample taking, and similar services, repair damaged construction and restore substrates and finishes.
 - 1. Provide materials and comply with installation requirements specified in other Specification Sections. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible.
 - 2. Comply with the Contract Document requirements for Division 01 Section "Cutting and Patching."
- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION 01 40 00

SECTION 016310 - SUBSTITUTIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for handling requests for substitutions.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 010950 "Reference Standards and Definitions" specifies the applicability of industry standards to products specified.
 - 2. Section 013000 "Submittals" specifies requirements for submitting the Contractor's Construction Schedule and the Submittal Schedule.
 - 3. Section 016000 "Materials and Equipment" specifies requirements governing the Contractor's selection of products and product options.
- C. Substitutions:
 - 1. After the Award of Contract:
 - a. The Procurement Division will consider a request by the contractor for substitution where the specified product cannot receive necessary approval by a governing authority, and the requested substitution can be approved.
 - b. The Procurement Division will consider a request by the Contractor for a substitution after the award of the Contract where substantial advantage is offered to the Owner in terms of:
 - 1) A credit is offered for substitution of a Product accepted as an approved equal to a specified item by the Architect.
 - 2) A Product has been accepted by the Architect as being of greater quality at no additional cost to the Owner.
 - 3) The Products specified, for no fault of the Contractor, cannot be obtained.
 - 4) The Architect will consider a request for substitution when the specified Product cannot be provided in a manner which is compatible with other materials of the work.
 - 5) The Architect will consider a request for substitution when the specified Product cannot be properly coordinated with other materials in the work

- 6) The Architect will consider a request for substitution when the specified Product cannot receive a warranty as required by the Contract Documents.
2. The Contractor, Subcontractor or Supplier who is recommending the Substitution shall compensate the Architect/Engineer for expenditures necessary in reviewing the proposed substitution. Prevailing hourly billing rates shall be used plus 20%.

1.3 DEFINITIONS

- A. Definitions in this Article do not change or modify the meaning of other terms used in the Contract Documents.
 1. Products, are items purchased for incorporation in the Work, regardless of whether they were specifically purchased for the project or taken from the Contractor's previously purchased stock. The term Product as used herein includes the terms "material," "equipment," "system" and other terms of similar intent.
 2. Named Products, are products identified by use of the manufacturer's name for a product, including such items as a make or model designation, as recorded in published product literature, of the latest issue as of the date of the contract documents.
 3. Materials, are products that must be substantially cut, shaped, worked, mixed, motorized or manually operated, and in particular, a product that requires service connections such as wiring or piping.
 4. Equipment, is defined as a product with operational parts, regardless of whether motorized or manually operated, and in particular, a product that requires service connections such as wiring or piping.
- B. Substitutions: Changes in products, materials, equipment, and methods of construction required by the Contract Documents. The following are not considered to be requests for substitutions:
 1. Revisions to the Contract Documents requested by the Owner, Architect or Engineers are considered as changes and not substitutions.
 2. Specified options of products and construction methods included in the Contract Documents.
 3. The Contractor's determination of and compliance with governing regulations and orders issued by governing authorities.

1.4 SUBMITTALS

- A. Substitution Request Submittal:
 1. Submit 6 copies of each request for substitution for consideration. Submit requests in the form and according to procedures required for change-order proposals.
 2. Identify the product or the fabrication or installation method to be replaced in each request. Include related Specification Section and Drawing numbers.

3. Provide complete documentation showing compliance with the requirements for substitutions, and the following information, as appropriate:
 - a. Coordination information, including a list of changes or modifications needed to other parts of the Work and or to construction necessary to accommodate the proposed substitution. The Contractor shall certify that the Substitution, if accepted, would be complete and no additional cost to the Owner would be required.
 - b. A detailed comparison of significant qualities of the proposed substitution with those of the Work specified. Significant qualities may include elements, such as performance, weight, size, durability, and visual effect.
 - c. Product Data, including Drawings and descriptions of products and fabrication and installation procedures.
 - d. Samples, where applicable or requested.
 - e. A statement indicating the substitution's effect on the Contractor's Construction Schedule compared to the schedule without approval of the substitution. Indicate the effect of the proposed substitution on overall Contract Time.
 - f. Cost information, including a proposal of the net change, if any to the Contract Sum.
 - g. The Contractor's certification that the proposed substitution conforms to requirements in the Contract Documents in every respect and is appropriate for the applications indicated.
 - h. The Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of the failure of the substitution to perform adequately.
4. Architect's Action: If necessary, the Architect will request additional information or documentation for evaluation within one week of receipt of a request for substitution. The Architect will notify the Contractor of acceptance or rejection of the substitution within 2 weeks of receipt of the request, or one week of receipt of additional information or documentation. Acceptance will be in the form of a change order.
 - a. Use the product specified if the Architect cannot make a decision on the use of a proposed substitute within the time allocated.

PART 2 - PRODUCTS

2.1 SUBSTITUTIONS

- A. Conditions: The Architect will receive and consider the Contractor's request for substitution when one or more of the following conditions are satisfied, as determined by the Architect. If the following conditions are not satisfied, the Architect will return the requests without action except to record noncompliance with these requirements.

1. Extensive revisions to the Contract Documents are not required.
 2. Proposed changes are in keeping with the general intent of the Contract Documents.
 3. The request is timely, fully documented, and properly submitted.
 4. The Architect will not consider the request if the specified product or method cannot be provided as a result of the Contractor failure to pursue the Work promptly or coordinate activities properly
 5. The requested substitution offers the Owner a substantial advantage, in cost, time, energy conservation, or other considerations.
 6. The specified product or method of construction cannot receive necessary approval by a governing authority, and the requested substitution can be approved.
 7. The specified product or method of construction cannot be provided in a manner that is compatible with other materials and where the Contractor certifies that the substitution will overcome the incompatibility.
 8. The specified product or method of construction cannot be coordinated with other materials and where the Contractor certifies that the proposed substitution can be coordinated.
 9. The specified product or method of construction cannot provide a warranty required by the Contract Documents and where the Contractor certifies that the proposed substitution provides the required warranty.
- B. The Contractor's submittal and the Architect's acceptance of Shop Drawings, Product Data, or Samples for construction activities not complying with the Contract Documents do not constitute an acceptable or valid request for substitution, nor do they constitute approval.

PART 3 - EXECUTION - (Not Applicable)

END OF SECTION

SECTION 01 73 29 - CUTTING AND PATCHING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes procedural requirements for cutting and patching.
- B. Related Sections include the following:
 - 1. Divisions 2 through 49 Sections for specific requirements and limitations applicable to cutting and patching individual parts of the Work.
 - 2. Division 07 Section "Penetration Firestopping" for patching fire-rated construction.

1.3 DEFINITIONS

- A. Cutting: Removal of in-place construction necessary to permit installation or performance of other Work.
- B. Patching: Fitting and repair work required to restore surfaces to original conditions after installation of other Work.

1.4 QUALITY ASSURANCE

- A. Structural Elements: Do not cut and patch structural elements in a manner that could change their load-carrying capacity or load-deflection ratio.
- B. Operational Elements: Do not cut and patch operating elements and related components in a manner that results in reducing their capacity to perform as intended or that results in increased maintenance or decreased operational life or safety.
- C. Miscellaneous Elements: Do not cut and patch miscellaneous elements or related components in a manner that could change their load-carrying capacity, that results in reducing their capacity to perform as intended, or that results in increased maintenance or decreased operational life or safety
- D. Visual Requirements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch construction exposed on the exterior or in occupied spaces in a manner that would, in Architect's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.
- E. Cutting and Patching Conference: Before proceeding, meet at Project site with parties involved in cutting and patching, including mechanical and electrical trades. Review areas of potential

interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.

1.5 WARRANTY

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

PART 2 - PRODUCTS

2.1 MATERIALS

- A. General: Comply with requirements specified in other Sections.
- B. In-Place Materials: Use materials identical to in-place materials. For exposed surfaces, use materials that visually match in-place adjacent surfaces to the fullest extent possible.
 - 1. If identical materials are unavailable or cannot be used, use materials that, when installed, will match the visual and functional performance of in-place materials.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine surfaces to be cut and patched and conditions under which cutting and patching are to be performed.
 - 1. Compatibility: Before patching, verify compatibility with and suitability of substrates, including compatibility with in-place finishes or primers.
 - 2. Proceed with installation only after unsafe or unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Temporary Support: Provide temporary support of Work to be cut.
- B. Protection: Protect in-place construction during cutting and patching to prevent damage. Provide protection from adverse weather conditions for portions of Project that might be exposed during cutting and patching operations.
- C. Adjoining Areas: Avoid interference with use of adjoining areas or interruption of free passage to adjoining areas.
- D. Existing Utility Services and Mechanical/Electrical Systems: Where existing services/systems are required to be removed, relocated, or abandoned, bypass such services/systems before cutting to prevent interruption to occupied areas.

3.3 PERFORMANCE

- A. General: Employ skilled workers to perform cutting and patching. Proceed with cutting and patching at the earliest feasible time, and complete without delay.
1. Cut in-place construction to provide for installation of other components or performance of other construction, and subsequently patch as required to restore surfaces to their original condition.
- B. Cutting: Cut in-place construction by sawing, drilling, breaking, chipping, grinding, and similar operations, including excavation, using methods least likely to damage elements retained or adjoining construction. If possible, review proposed procedures with original Installer; comply with original Installer's written recommendations.
1. In general, use hand or small power tools designed for sawing and grinding, not hammering and chopping. Cut holes and slots as small as possible, neatly to size required, and with minimum disturbance of adjacent surfaces. Temporarily cover openings when not in use.
 2. Finished Surfaces: Cut or drill from the exposed or finished side into concealed surfaces.
 3. Concrete and Masonry: Cut using a cutting machine, such as an abrasive saw or a diamond-core drill.
 4. Excavating and Backfilling: Comply with requirements in applicable Division 31 Sections where required by cutting and patching operations.
 5. Mechanical and Electrical Services: Cut off pipe or conduit in walls or partitions to be removed. Cap, valve, or plug and seal remaining portion of pipe or conduit to prevent entrance of moisture or other foreign matter after cutting.
 6. Proceed with patching after construction operations requiring cutting are complete.
- C. Patching: Patch construction by filling, repairing, refinishing, closing up, and similar operations following performance of other Work. Patch with durable seams that are as invisible as possible. Provide materials and comply with installation requirements specified in other Sections.
1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate integrity of installation.
 2. Exposed Finishes: Restore exposed finishes of patched areas and extend finish restoration into retained adjoining construction in a manner that will eliminate evidence of patching and refinishing.
 - a. Clean piping, conduit, and similar features before applying paint or other finishing materials.
 - b. Restore damaged pipe covering to its original condition.
 3. Floors and Walls: Where walls or partitions that are removed extend one finished area into another, patch and repair floor and wall surfaces in the new space. Provide an even surface of uniform finish, color, texture, and appearance. Remove in-place floor and wall coverings and replace with new materials, if necessary, to achieve uniform color and appearance.
 - a. Where patching occurs in a painted surface, apply primer and intermediate paint coats over the patch and apply final paint coat over entire unbroken surface containing the patch. Provide additional coats until patch blends with adjacent surfaces.

4. Ceilings: Patch, repair, or rehang in-place ceilings as necessary to provide an even-plane surface of uniform appearance.
 5. Exterior Building Enclosure: Patch components in a manner that restores enclosure to a weathertight condition.
- D. Cleaning: Clean areas and spaces where cutting and patching are performed. Completely remove paint, mortar, oils, putty, and similar materials.

END OF SECTION 01 73 29

SECTION 017400 - WARRANTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for warranties required by the Contract Documents, including manufacturers standard warranties on products and special warranties.
 - 1. Refer to the General Conditions for terms of the Contractor's period for correction of the Work.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Section 013000 "Submittals" specifies procedures for submitting warranties.
 - 2. Section 017000 "Contract Closeout" specifies contract closeout procedures.
 - 3. Divisions 26 and 28 Sections for specific requirements for warranties on products and installations specified to be warranted.
 - 4. Certifications and other commitments and agreements for continuing services to Owner are specified elsewhere in the Contract Documents.
- C. Disclaimers and Limitations: Manufacturer's disclaimers and limitations on product warranties do not relieve the Contractor of the warranty on the Work that incorporates the products. Manufacturer's disclaimers and limitations on product warranties do not relieve suppliers, manufacturers, and subcontractors required to countersign special warranties with the Contractor.

1.3 DEFINITIONS

- A. Standard product warranties are preprinted written warranties published by individual manufacturers for particular products and are specifically endorsed by the manufacturer to the Owner.
- B. Special warranties are written warranties required by or incorporated in the Contract Documents, either to extend time limits provided by standard warranties or to provide greater rights for the Owner.

1.4 WARRANTY REQUIREMENTS

- A. Related Damages and Losses: When correcting failed or damaged warranted construction, remove and replace construction that has been damaged as a result of such failure or must be removed and replaced to provide access for correction of warranted construction.
- B. Reinstatement of Warranty: When Work covered by a warranty has failed and been corrected by replacement or rebuilding, reinstate the warranty by written endorsement. The reinstated warranty shall be equal to the original warranty with an equitable adjustment for depreciation.
- C. Replacement Cost: Upon determination that Work covered by a warranty has failed, replace or rebuild the Work to an acceptable condition complying with requirements of the Contract Documents. The Contractor is responsible for the cost of replacing or rebuilding defective Work regardless of whether the Owner has benefited from use of the Work through a portion of its anticipated useful service life.
- D. Owner's Recourse: Expressed warranties made to the Owner are in addition to implied warranties and shall not limit the duties, obligations, rights, and remedies otherwise available under the law. Expressed warranty periods shall not be interpreted as limitations on the time in which the Owner can enforce such other duties, obligations, rights, or remedies.
 - 1. Rejection of Warranties: The Owner reserves the right to reject warranties and to limit selection to products with warranties not in conflict with requirements of the Contract Documents.
- E. Where the Contract Documents require a special warranty, or similar commitment on the Work or part of the Work, the Owner reserves the right to refuse to accept the Work, until the Contractor presents evidence that entities required to countersign such commitments are willing to do so.

1.5 SUBMITTALS

- A. Submit written warranties to the Owner as part of the close-out documents. The Owner's Certificate of Substantial Completion designates the commencement date for warranties.
 - 1. When a designated portion of the Work is completed and occupied or used by the Owner, by separate agreement with the Contractor during the construction period, submit properly executed warranties to the Owner within 15 days of completion of that designated portion of the Work.
- B. When the Contract Documents require the Contractor, or the Contractor and a subcontractor, supplier or manufacturer to execute a special warranty, prepare a written document that contains appropriate terms and identification, ready for execution by the

required parties. Submit a draft to the Owner, through the Owner, for approval prior to final execution.

1. Refer to Divisions 2 through 16 Sections for specific content requirements and particular requirements for submitting special warranties.
- C. Form of Submittal: At Final Completion compile 2 copies of each required warranty properly executed by the Contractor, or by the Contractor, subcontractor, supplier, or manufacturer. Organize the warranty documents into an orderly sequence based on the table of contents of the Project Manual.
- D. Bind warranties and bonds in heavy-duty, commercial-quality, durable 3-ring, vinyl-covered loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.
1. Provide heavy paper dividers with celluloid covered tabs for each separate warranty. Mark the tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product, and the name, address, and telephone number of the Installer.
 2. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project title or name, and name of the Contractor.
 3. When warranted construction requires operation and maintenance manuals, provide additional copies of each required warranty, as necessary, for inclusion in each required manual.

PART 2 - PRODUCTS - (Not Applicable)

PART 3 - EXECUTION

3.1 LIST OF WARRANTIES

- A. Schedule: Provide a Warranties Schedule on products and installations of items which will require the Contractor to provide warranties with the close-out documents. This schedule shall be submitted with the Submittal Schedule.

END OF SECTION

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SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:
 - 1. Substantial Completion procedures.
 - 2. Final completion procedures.
 - 3. Warranties.
 - 4. Final cleaning.
 - 5. Repair of the Work.
 - 6. All Closeout Deliverables shall be submitted to Owner in electronic format unless specifically noted otherwise herein.
- B. Related Requirements:
 - 1. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.
 - 2. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.

1.3 DEFINITIONS

- A. Closeout Manuals: Manuals containing documentation required for closeout procedure verification. Three (3) separate PDF manuals, as follows: Architectural, Mechanical/Plumbing and Electrical.
- B. Environmental Closeout Manual: Collection of PDF documents certifying to OWNER that Project was permitted, constructed, and inspected in compliance with all regulatory requirements, the required disposals and/or recycling activities were documented and certified, all inspections and final clearances required by AHJs have been issued/filed, MSDS information has been submitted, and all notable environmental occurrences related to Project are documented and filed.
 - 1. Due from A/E at Substantial Completion. CM/GC shall submit to A/E prior to Substantial Completion for A/E's review and approval.
 - 2. Separate PDF files are required for each document listed in the Environmental Closeout Checklist. Each category and all subcategories of files must be bookmarked.
 - 3. Once manual is approved by A/E, CM/GC shall complete and submit the Environmental Affairs Project Closeout Checklist to PM. PM shall submit to OWNER Director of Environmental Compliance for review/approval.

4. OWNER Environmental Compliance will review and provide final signature of approval on the Environmental Affairs Project Closeout Checklist.
 5. CM/GC to provide written, signed statement that delineates any major environmental divisions that are not applicable to the project. If all divisions apply, the Contractor shall so state.
- C. Warranties & Guarantees Manual, Hard Copy: One (1) hard-copy binder including originals of each Warranty and/or Guarantee as required by Architect's Project Specification Sections.
 - D. A/E Consolidated Punch List Sign-Off: Master Consolidated Punch List includes all Punch Lists from OWNER Maintenance and each OWNER Stakeholder, PM Team, along with each Engineer, Designer, and Sub-Consultant. Each item on the Final Punch List must be initialed/dated by the Author as "COMPLETE", and merged into (1) final PDF document.
 - E. General Requirements Sign-Off: Listing of every item procured with General Requirements funding by CM/GC at \$75 or more, including date and signature of OWNER representative authorized to assume possession of item at completion of Project.
 - F. As-Built Drawings: During Construction, kept at Project site and updated on a weekly basis to reflect ASIs, Bulletins, PRs, RFIs, and all other field adjustments.
 - G. As-Built Manuals: During Construction, kept at Project site and updated on weekly basis with selected/approved/installed manufacturers and model numbers circled. Unused items are stricken-through.
 - H. Certificate of Occupancy: Issued by the Building Code Compliance Office (BCCO) documenting, "the described structure or portion of the structure has been inspected for compliance with the requirements of the FBC for the occupancy and division of occupancy and the use for which the occupancy is classified."
 - I. Certificate of Substantial Completion: Four (4) originals of OWNER Form "CP 1510" to be signed by CM/GC, A/E, and OWNER, which states that the Architect/Engineer has inspected the subject property, and the Work is found to be substantially and sufficiently complete in accordance with the approved Contract documents so that the Owner can occupy or utilize the Work for its intended use. Date of Substantial Completion signifies initial commencement of the Warranty Period, and date on which OWNER Maintenance becomes responsible for continuing care, maintenance and warranty protection. Four (4) originals shall be distributed as follows: OWNER A/E, CM/GC, spare.
 - J. Record Drawings and Record Project Manuals: Final version of Construction Documents (Drawings and Project Manuals) which incorporate all As-Built information provided by the CM/GC to the Architect and verified by the PM Team.
 - K. Final OWNER Pay Application: One (1) signed/notarized packet, including insurance certificates, contractor's affidavit of payment of debts and claims, contractor's affidavit of release of Liens, consent of surety to final payment, evidence that claims have been settled, final liquidated damages settlement statement, final M/WBE report, identify GR Savings, identify Buy-out Savings, identify self-perform work.
 - L. OEF 564 Cost Breakdown Information: CM/GC shall provide OWNER with accurate, comprehensive information regarding final Cost of Construction amounts for specific categories of scopes of work included in the CM/GC's contract. OWNER is required to report this information, along with other Project costs, to the Department of Education at Project Completion.

1.4 ACTION SUBMITTALS

- A. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.
- B. Certified List of Incomplete Items: Final submittal at Final Completion.

1.5 CLOSEOUT SUBMITTALS

- A. Certificates of Release: From authorities having jurisdiction.
- B. Certificate of Insurance: For continuing coverage.
- C. Closeout Process:

1. Pre-Closeout Meeting:

- a. Shall be held a minimum of 30-days in advance of the projected Substantial Completion inspection. Purpose of the meeting is to review all Closeout deliverables, and establish a tentative date for the Substantial Completion Inspection. PM shall provide 2-weeks advance notification to all invited attendees.

2. Review of Closeout Deliverables:

- a. CM/GC submits to Architect: For each Closeout Deliverable, CM/GC shall submit to Architect per the due dates listed in enclosed "Closeout Deliverable Schedule". 1. After submitting the set due at 50% Construction Completion, partial submittals shall not be accepted, with the exception of Phased Projects which have individual Contractual Substantial Completion dates.
- b. Architect performs review: Architect shall review each Closeout Deliverable within the allotted time frame required by the OWNER/Architect contract for "Submittal Review Time".
- c. Architect submits to PM Team: Architect will then attach transmittal with review stamp and date to the Closeout deliverable, upload to OWNER' FTP site, and send email notification to Design.Construction@OWNER.net, the PM, and the PM Team's Closeout Manager.
- d. PM Team performs review: Once reviewed by Architect, the PM Team's Closeout Manager will review with PM staff and forward review comments to Architect and CM/GC.
- e. PM Team submits to OWNER: After PM Team reviews and approves each Closeout Deliverable, PM Team shall submit deliverable with transmittal to OWNER. Transmittal will clearly identify location of item on OWNER Facilities Server.
- f. NOTE: When Architect uploads Closeout Deliverables to PM Team, Architect shall clearly identify item as Closeout.

3. Confirmation of Approval for Closeout Deliverables:

- a. The Project Closeout Checklist shall serve as the final confirmation of OWNER' acceptance of all Closeout Deliverables.
- b. The PM Team will insert completion dates on this checklist as progress is made.

- c. Once all deliverables are satisfied, the PM Team will circulate for electronic signatures.
 - 1. Order of signatures is as follows:
 - a. CM/GC
 - b. Architect of Record
 - c. PM (PM Team's Closeout Manager to Initial)
 - d. Facilities Project Manager, P&D (Planning/Archives Team Member to Initial)
 - e. Facilities Program Director, Construction
 - f. Senior Director Facilities, Construction
 - d. Fully executed "Project Closeout Checklist" is required to be presented with CFI during Document Review meeting.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Schedule of Maintenance Material Items: For maintenance material submittal items specified in other Sections.

1.7 CLOSE OUT DOCUMENTATION AND PROCEDURES

- a. Initial Submittal of all Closeout Manuals are due at 50% Construction Completion.
- b. Electronic Manual Submittals: One (1) PDF file is required for each of the following manuals:
 - 1. Architectural
 - 2. Mechanical / Plumbing
 - 3. Electrical
- c. For Electronic Manual Submittals, page 1 of each PDF shall be "Project Information Sheet". Each PDF file shall be bookmarked per Specification Section (number and name). Each bookmarked section shall contain five (5) bookmarks for each of the five (5) documents listed below. *Note: If a particular Specification Section does not require one or more of the five (5) documents listed below, insert a placeholder sheet stating, "Not Required per Specification Section".*
 - 1. Specification Section Information Sheet
 - 2. O&M Material (*required for each type of product/equipment*)
 - a. Manufacturer's Recommended Care and Cleaning
 - b. Installation Instructions
 - c. Manufacturer's parts lists including parts numbers
 - d. Filter Lists including sizes, locations and replacement schedule
 - e. Lubrication charts and schedules

- f. Valve charts and schedules
 - g. Schematic piping and wiring diagrams
 - h. Pertinent diagrams of equipment with main parts identification
 - i. Special instructions
 - j. Any testing procedures for operating tests
 - k. Preventative Maintenance Instructions
 - l. Emergency instructions
 - m. Inspection Procedures
3. Copy of Warranties & Guarantees
- a. In the event warranties require Owner signature, the Facilities Program Director shall sign only after receiving:
 - 1. Summary from the PM stating where the warranty is referenced in the contract documents.
 - 2. Confirmation from the AE that said warranty meets the intent of the contract documents.
 - 3. Confirmation from the PM that the warranty complies with the contract documents with recommendation to execute.
4. Spare Parts / Maintenance Stock
- a. Submittal Register shall include required quantities and types for all spare parts / maintenance stock.
 - b. At minimum (2) weeks in advance of delivery date, draft Exhibit Ds listing the following information shall be submitted to Architect and PM Team for pre-approval: quantity and type of each item listed on Equipment Schedule and/or Finish Schedule. Form must be approved by Architect and PM Team in advance of delivering attic stock to OWNER.
 - c. During Pre-Closeout Meeting, PM shall define OWNER delivery address for each item (information provided by Area O&M Manager).
 - d. CM/GC shall secure signature of PM in advance of delivering attic stock to OWNER.
 - f. Coordinate delivery dates/times in advance with OWNER Maintenance Representative Recipient.
 - g. CM/GC shall deliver to OWNER Area Maintenance at Substantial Completion.
 - h. When possible, label each package/box/container with description or ID tag from Architect's Finish Schedule or Equipment Schedule.
 - i. CM/GC to include completed/signed Exhibit Ds (transmittal sheet) in each Closeout Manual, which is due to the PM Team from A/E within (30) calendar days of Substantial Completion. When possible, include description or ID tag from Architect's Finish Schedule on Exhibit D.
5. Performance Verification/Demonstration to Owner
- a. CM/GC to include all training requirements within Closeout Submittal Register, due to A/E within (30) days of NTP.
 - b. During Pre-Closeout Meeting, define requirements of each training session.
 - c. Coordinate dates/times with each required Attendee, including; OWNER, Maintenance, and all related OWNER Stakeholders.
 - d. The manufacturer's representative and system consultant shall be present
 - e. Submit proof of start-up/final testing of systems.
 - f. CM/GC to include Exhibit E's (sign-in sheets) in each Closeout Manual, which is due to the PM Team from A/E within (30) calendar days of Substantial Completion.

- g. CM/GC to submit video documentation of each training session to A/E within (30) calendar days of Substantial Completion. Video must be in mpg format.
- h. Develop a description of specific skills and knowledge that participants are expected to master. Include instruction for the following as applicable to the system, equipment, or component.
 - 4. Basis of System Design, Operational Requirements, and Criteria: Include the following:
 - a. System, subsystem, and equipment descriptions
 - b. Performance and design criteria if Contractor is delegated design responsibility
 - c. Operating standards
 - d. Regulatory requirements
 - e. Equipment function
 - f. Operating characteristics
 - g. Limiting conditions
 - h. Performance curves
 - 5. Documentation: Review the following items in detail:
 - a. Emergency manuals
 - b. Operations manuals
 - c. Maintenance manuals
 - d. Project record documents
 - e. Identification systems
 - f. Warranties and bonds
 - g. Maintenance service agreements and similar continuing commitments.
 - 6. Emergencies: Include the following, as applicable:
 - a. Instructions on meaning of warnings, trouble indications, and error messages.
 - b. Instructions on stopping.
 - c. Shutdown instructions for each type of emergency.
 - d. Operating instructions for conditions outside of normal operating limits.
 - e. Sequences for electric or electronic systems.
 - f. Special operating instructions and procedures
 - 7. Operations: Include the following, as applicable:
 - a. Startup procedures
 - b. Equipment or system break-in procedures
 - c. Routine and normal operating instructions
 - d. Regulation and control procedures
 - e. Control sequences
 - f. Safety procedures
 - g. Instructions on stopping
 - h. Normal shutdown instructions
 - i. Operating procedures for emergencies
 - j. Operating procedures for system, subsystem, or equipment failure
 - k. Seasonal and weekend operating instructions
 - l. Required sequences for electric or electronic systems
 - m. Special operating instructions and procedures
 - 8. Adjustments: Include the following:
 - a. Alignments
 - b. Checking adjustments
 - c. Noise and vibration adjustments
 - d. Economy and efficiency adjustments
 - 9. Troubleshooting: Include the following:
 - a. Diagnostic instructions
 - b. Test and inspection procedures

10. Maintenance: Include the following:
 - a. Inspection procedures
 - b. Types of cleaning agents to be used and methods of cleaning
 - c. List of cleaning agents and methods of cleaning detrimental to product
 - d. Procedures for routine cleaning
 - e. Procedures for preventive maintenance
 - f. Procedures for routine maintenance
 - g. Instruction on use of special tools

11. Repairs: Include the following:
 - a. Diagnosis instructions
 - b. Repair instructions
 - c. Disassembly; component removal, repair, and replacement; and reassembly instructions
 - d. Instructions for identifying parts and components
 - e. Review of spare parts needed for operation and maintenance

e. Environmental Closeout Manual

1. Due from A/E at Substantial Completion. CM/GC shall submit to A/E prior to Substantial Completion for A/E's review and approval.
2. Separate PDF files are required for each document listed in the Environmental Close-out Manual Checklist (Exhibit J). Each category and all subcategories of files must be bookmarked.
3. Once manual is approved by A/E, CM/GC shall complete and submit the Environmental Affairs Project Closeout Checklist (Exhibit I) to PM. PM shall submit to OWNER Director of Environmental Compliance for review/approval.
4. OWNER Environmental Compliance' will review and provide final signature of approval on the Environmental Affairs Project Closeout Checklist (Exhibit I).
5. CM/GC to provide written, signed statement that delineates any major environmental divisions that are not applicable to the project. If all divisions apply, the Contractor shall so state.

f. Original Copy Submittals for Warranties & Guarantees: Organize submittal as follows:

1. Due from A/E within (30) calendar days of Substantial Completion.
2. In addition to including copy of Warranty in the (5) Closeout Manuals listed above (Arch/Civil; Mechanical/Plumbing; Electrical; Fire; Kitchen), CM/GC shall also submit (1) hard copy binder of all original Warranties & Guarantees.
3. Binder shall include Table of Contents, inclusive of the following:
 - a. Warranties & Guarantees in order of Specification Section number.
 - b. Product Name
 - c. Type of Warranty

- d. Number of Years included with Warranty
 - e. Subcontractor Name
 - f. Subcontractor Telephone Number
4. NOTE: In the event warranties require Owner signature, the Facilities Program Director shall sign only after receiving:
- a. Summary from the PM stating where the warranty is referenced in the contract documents.
 - b. Confirmation from the AE that said warranty meets the intent of the contract documents.
 - c. Confirmation from the PM that the warranty complies with the contract documents with recommendation to execute.
5. Binder shall be clear vinyl covered, 3-ring binder, 3" maximum
- a. Use additional binder if needed.
 - b. Sparco "Standard Vue Binders", Series SPR 057 Series, up to 1-1/2", or equivalent; SPR 062 Series/D-Ring 2" to 3", or equivalent.
 - c. Each section shall be divided by 8-1/2" x 11" reinforced white blank indexes, 3-hole punched, with clear tab labels for laser printing, 5-tab dividers.
 - 1. Avery Series AVE 11446, or equivalent.
 - 2. See Exhibits B and C for cover layout.
 - 3. Tab labels shall be clearly marked with Division Number.
5. A/E Master Consolidated Punch List Sign-Off
- a. Conduct Pre-Inspection of Punch List Walk-Through with OWNER and Opening Team Members.
 - b. Ensure CM/GC has pre-punched prior to requesting A/E & Client walk-through.
 - c. Require CM/GC to notify A/E in writing upon CM/GC's completion of Punch List items.
 - d. Send meeting invitations to each OWNER Stakeholder identified on "Punch List Checklist" no later than 2-weeks prior to inspection date.
 - e. PM to participate in each inspection, and forward all OWNER lists to A/E.
 - f. PM to ensure OWNER Stakeholders' lists are included in A/E's Master Consolidated Punch List.
 - g. PM to schedule and participate in re-inspections.
 - h. PM to ensure CM/GC completion of Punch List within time allotted by Contract (typically within 30 days of Substantial Completion) to minimize occurrence of extending Conditional Certificates of Occupancy (CCOs).
 - i. PM to monitor OWNER Commissioning Server, to track OWNER Maintenance' sign-off on all Punch List items.
 - j. Each line of Consolidated Punch List must be signed /dated by Author of Punch List Item.

6. General Requirements Sign-Off

- a. Upon receipt of Contractor's initial Pay Application, and applicable for each Pay Application thereafter, Project Manager shall maintain a log of items purchased by Contractor with General Requirements (GR) funding. This log shall be referred to as "GR Inventory Log".
- b. Criteria for determining if items qualify for inclusion in GR Inventory Log are as follows:
 1. Items valued at \$75 or above
 2. Items must have pre-qualified as an allowable purchase per contract language
- c. GR Inventory Log shall include the following criteria:
 1. Pay Application number
 2. GR Schedule of Values (SOV) line item number
 3. Description of item
 4. Manufacturer or retail outlet
 5. Amount paid by Contractor (exclusive of sales tax)
- d. Project Manager shall share GR Inventory Log with Contractor on a monthly basis in an effort to maintain agreement and eliminate issues in reconciliation at time of Project Close-out.
- e. At time of Project Closeout, Contractor shall be required to account for each item listed in GR Inventory Log, as follows:
 1. Return to OWNER all items listed in GR Inventory Log in working order & good condition.
 2. Contractor shall create transmittal for all items to be returned to OWNER.
 3. Ensure all titles for each item, if available, or properly and thoroughly transferred to OWNER.
 4. Contractor shall secure signed and dated transmittal from OWNER for each item re-turned.
 5. Project Manager shall verify each printed name on all transmittals are legible, and shall ensure all transmittals are properly included in OWNER Closeout files.
- f. Provide credit to OWNER from amounts realized from sale of unused or excess materials or items.
- g. In the event a Project Manager is assigned to a Project after OWNER' processing of initial and subsequent Pay Applications, Project Manager shall retrieve copies of all past Pay Applications and use this historic information to populate GR Inventory Log.

7. As-Built Drawings & As-Built Manuals:

- a. CM/GC shall be responsible for recording daily deviations of construction on a copy of the Conformed Construction Documents kept at the project site.
- b. CM/GC shall maintain a clean, undamaged set of Conformed Contract Documents (blue or black line prints of drawings and Project Manuals) and ensure they are regularly and promptly marked to show the actual conditions where actual installation, material, equipment or location varies from the Work as shown in the Conformed Documents.

1. All such variations shall be marked in red on the As-Built Drawings and the As-Built Project Manual(s) at the time of occurrence to ensure accuracy.
 2. Mark drawings and pages that are the most capable of showing conditions fully and accurately.
 3. Particular attention shall be given to concealed elements that would be difficult to measure and record at a later date.
 4. Record information on the Work that is shown only schematically
 5. Post RFI's, ASI's, Change Orders, Addenda, etc. continuously during Construction.
 6. Mark actual products installed in Project (Specification) Manuals for A/E to highlight in Record Set.
 7. Schedule review session at 50% Construction Completion to review As-Built documents with all Engineers and Sub-Consultants.
 8. Discuss turnover of As-Built documents during Pre-Closeout Meeting, and at 30-days prior to scheduled date of Substantial Completion.
 9. "As-Built Documents" shall be reviewed by the Architect and Project Manager at Project Meetings, at least monthly to insure they are being kept up to date.
 - c. CM/GC shall submit their As-Built Conformed Contract Documents to the Architect as color scanned PDF files with each PDF file named per Architect sheet name at Substantial Completion.
 1. Meet with A/E and PM Team to page-turn to ensure complete/clear information is being provided.
 - d. A/E shall upload As-Built Documents to OWNER' FTP site. Electronic color copies are required; hard copies are accepted but not required.
8. Certificate of Occupancy (*fully executed certificate issued by BCCO*)
- a. CM/GC shall ensure all requirements for requesting Certificate of Occupancy are satisfied/inspected (reference BCCO website for current requirements), and all conditions previously listed on Conditional Certificate(s) of Occupancy have been completed.
 - b. CM/GC shall forward request for Certificate of Occupancy to the BCCO, ensuring all fields of form are completed with required information (Project information, construction type, square footage, occupant load, description of each structure, contact information, permit information, final inspection dates, etc).
 - c. BCCO will review, process, and issue (email) completed forms (signed/dated by the Building Official).
 - d. CM/GC shall provide copies of all Certificate of Occupancy forms to the PM Team for filing in the Project folder of the OWNER Facilities Server.
9. Certificate of Substantial Completion (4 Originals)
- a. CM/GC shall prepare and submit the following documentation to the Architect prior to requesting inspection for certification of Substantial Completion. Architect shall review, approve/stamp. Partial submittals shall not be accepted, except for Projects with multiple contractual Substantial Completion dates.

1. Certificate(s) of Occupancy (or CCO) issued by BCCO
 2. CM/GC's Completion Punch List (List of items to be completed or corrected)
 3. Environmental Affairs Project Closeout Checklist
 4. As-Built Drawings & As-Built Project
- a. Upon receipt of the CM/GC's written request for inspection, Architect shall verify that the CM/GC has submitted all required Closeout Deliverables which are due at time of Substantial Completion (see enclosed "Closeout Deliverables Schedule"), or notify CM/GC of non-compliance and failure to demonstrate readiness for Substantial Completion inspection.
1. Once Architect is in agreement with CM/GC's readiness for Substantial Completion inspection, PM shall establish date, and distribute invite to OWNER attendees.
 - a. The following parties shall attend: PM, CM/GC and Primary Sub-Contractors, Architect, Primary Engineering Consultants and Designers, and OWNER Maintenance.
 2. At such time as the Work has been deemed Substantially Complete, Architect shall prepare the Certificate of Substantial Completion (*OWNER Form "CP 1510"; four originals*), stating that the Architect/Engineer has inspected the subject property, and the Work is found to be substantially and sufficiently complete in accordance with the approved Contract documents so that the Owner can occupy or utilize the Work for its intended use.
 - a. Prior to executing the Certificate of Substantial Completion (*OWNER Form "CP 1510"*), Architect shall submit Master Consolidated Punch List.
 1. Shall include all Punch List inspection items received from all Sub-Consultants, Engineers/Designers, CM/GC, OWNER Maintenance, and all OWNER Stakeholders (see OWNER Punch List Checklist for listing of OWNER Punch Lists).
 2. Shall be prepared within five (5) days of the last inspection performed.
 3. Cover sheet shall be the OWNER Punch List Checklist, provided by PM and completed/signed by the Architect.
 - b. Punch List Checklist shall be attached to each of the (4) original Certificate of Substantial Completion forms. It is not necessary to attach the entire Master Consolidated Punch List to the Certificate of Substantial Completion forms.
 - c. PM shall review, approve, and initial each of the (4) original Certificate of Substantial Completion packets, and submit to Senior Director of Construction for final signature.
 - d. Once fully executed, PM shall scan/email copies of the Certificate of Substantial Completion to Architect and CM/GC, save scanned copy to the Project Files on the OWNER Facilities Server, and transmit originals to Architect, CM/GC, and OWNER Archives. When transmitting files, PM shall use the PM Transmittal template.
 - e. Certificate of Substantial Completion does not authorize occupancy of any kind. Occupancy may only be obtained through a BCCO-issued Certificate of Occupancy (CO), or Conditional Certificate of Occupancy (CCO).

f. Certificate of Occupancy (CO), or Conditional Certificate of Occupancy (CCO), does not guarantee the Project has achieved Substantial Completion. This determination is made by the Architect in conjunction with the PM Team and ultimately approved by OWNER Senior Director of Construction.

3. At such time as the Work has been deemed Substantially Complete, the PM shall pre-prepare an OWNER Maintenance Receipt for Project Turnover (*Exhibit G*) signifying that OWNER Area Maintenance received the above project on a certain date and became responsible for its continuing care, maintenance and warranty protection.

10. Certificate of Final Inspection (4 Originals)

b. Certificate of Final Inspection serves as verification of the following:

1. Architect of Record documents the Work required by the Contract has been inspected, and has been completed in accordance with approved Contract documents.
2. Building Official documents the Project has been inspected, and is complete and in accordance with applicable statutes, rules and codes.
3. OWNER Board has accepted the referenced Project upon the recommendation of the Project Architect and in accordance with Chapter 1013 of Florida Statute.

c. A/E Generates Certificate of Final Inspection (4 originals).

d. BCCO Confirms and Signs CFI (4 originals).

e. PM Prepares Board Resolution paperwork, and attaches (4) original CFIs.

f. PM submits Board Resolution packet with request to be placed on Agenda.

g. Ensure the proper Board Resolution cover sheet is utilized when preparing paperwork.

1. All dollar amounts must be rounded to the nearest dollar.
2. Include Pre-Construction Fees in "Final Construction Contract Amount".
3. Final paperwork must be submitted to PM Team Leadership 3 weeks prior to Board Resolution date. PM Team Leadership will forward to OWNER CFO (2) full weeks prior to Board Resolution date.

h. CFI is not required to be presented to CPSC.

i. Regardless of the existence of multiple contractual Substantial Completion dates, only one (1) CFI is required for each Project.

j. Regardless of the number of GMP Amendments, only one (1) CFI is required for each Project.

1. For example, this shall apply in the event an additional Amendment was issued for construction of separate Classroom building; however both Amendments share same Project Number and Project Budget.
2. The financial portion of the CFI (typically second page) shall be divided into multiple sections to allow for each Amendment to be shown individually.

k. Final payment to CM/GC

1. Final payment to CM/GC shall occur approximately 2 weeks after CFI is approved.
- l. Upon fully executed CFI, OWNER submits for DOE release.
- m. OWNER Maintenance has responsibility for Warranty and continuing maintenance for facilities beginning with the date of Substantial Completion.

11. Record Drawings & Record Manuals:

- a. A/E and CM/GC are required to attend a review session with the PM Team to validate each sheet of submittal.
- b. A/E shall upload to OWNER' FTP site within thirty (30) days of Substantial Completion, and prior to the issuance of CFI.
 1. Must be in .dwg format.
 2. Can also submit in .dwf format.
 3. Each drawing sheet must read, "Record Drawings" with date.
 4. Record Manuals must be highlighted by A/E indicating final product approved/installed.
 5. It is not necessary for A/E to submit hard copy of Record Manuals. Electronic, book-marked copies are required.
 6. Record Drawings & Record Manuals are essentially 'cleaned up' copies of As-Built Drawings & Manuals. Ensure information from As-Builts is thoroughly captured in Record Drawings. Include the following, at minimum:
 - a. Dimensional changes to Drawings
 - b. Revisions to details shown on Drawings
 - c. Depths of foundations below first floor
 - d. Revisions to routing of piping and conduits
 - e. Revisions to electrical circuitry
 - f. Actual equipment locations
 - g. Duct size and routing
 - h. Changes made by Change Order or Construction Change Directive
 - i. Changes made following Architect's written orders
 - j. Details not on the original Contract Drawings
 - k. Field records for variable and concealed conditions
 - l. Location and depths of interior and exterior underground utilities and appurtenances, pull boxes, valves, shut offs, dimensionally referenced to permanent and visible surface improvements

- m. Final vertical elevations of all underground storm sewer, sanitary, water and gas systems referenced to permanent above ground surfaces
- n. Final perimeters and depths of all water retention areas sufficient for the calculation of as-built retention volume by A/E.
- o. CM/GC shall retain and pay for the services of a professionally licensed surveyor to certify elevations, locations, perimeters and depths.

12. Certified Final Payment Application (1 Original)

- a. Originals must be submitted to OWNER Fiscal; scanned copies of originals are placed in the Closeout file.
 - 1. Final MWBE Form
 - 2. Final Release of Liens from all Subcontractors/Suppliers
 - 3. Release & Affidavit Original from CM/GC, for the full and final contract amount.
 - 4. Consent of Surety with Power of Attorney (Original)
 - 5. Certificate(s) of Insurance (Original Certificate(s) for a Period of one (1) Year after Date of Substantial Completion). Terms of insurance shall be in conformance with specific requirements of the Contract documents.

1.8 SUBSTANTIAL COMPLETION PROCEDURES

- A. Contractor's List of Incomplete Items: Prepare and submit a list of items to be completed and corrected (Contractor's punch list), indicating the value of each item on the list and reasons why the Work is incomplete.
- B. Procedures Prior to Substantial Completion: Complete the following a minimum of 10 days prior to requesting inspection for determining date of Substantial Completion. List items below that are incomplete at time of request.
 - 1. Advise Owner of pending insurance changeover requirements.
 - 2. Make final changeover of permanent locks and deliver keys to Owner. Advise Owner's personnel of changeover in security provisions.
 - 3. Complete startup and testing of systems and equipment.
 - 4. Perform preventive maintenance on equipment used prior to Substantial Completion.
 - 5. Instruct Owner's personnel in operation, adjustment, and maintenance of products, equipment, and systems.
 - 6. Advise Owner of changeover in heat and other utilities.
 - 7. Participate with Owner in conducting inspection and walkthrough.
 - 8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
 - 9. Complete final cleaning requirements, including touchup painting.
 - 10. Touch up and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- C. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of 10 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Architect and Construction Manager will either proceed with

inspection or notify Contractor of unfulfilled requirements. Architect will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Architect, that must be completed or corrected before certificate will be issued.

1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.
2. Results of completed inspection will form the basis of requirements for final completion.

1.9 FINAL COMPLETION PROCEDURES

- A. Submittals Prior to Final Completion: Before requesting final inspection for determining final completion, complete the following:
 1. Certified List of Incomplete Items: Submit certified copy of Architect's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Architect. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
- B. Inspection: Submit a written request for final inspection to determine acceptance a minimum of 10 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Architect and Construction Manager will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.
 1. Reinspection: Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.10 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

- A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.
 1. Organize list of spaces in sequential order, starting with exterior areas first and proceeding from lowest floor to highest floor.
 2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
 3. Include the following information at the top of each page:
 - a. Project name.
 - b. Date.
 - c. Name of Architect and Construction Manager.
 - d. Name of Contractor.
 - e. Page number.
 4. Submit list of incomplete items in the following format:
 - a. MS Excel electronic file. Architect, through Construction Manager, will return annotated file.
 - b. PDF electronic file. Architect, through Construction Manager, will return annotated file.

- c. Three paper copies. Architect, through Construction Manager, will return two copies.

PART 2 - PRODUCTS

2.1 MATERIALS

- A. Cleaning Agents: Use cleaning materials and agents recommended by manufacturer or fabricator of the surface to be cleaned. Do not use cleaning agents that are potentially hazardous to health or property or that might damage finished surfaces.
 1. Use cleaning products that comply with Green Seal's GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.1 FINAL CLEANING

- A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.
- B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.
 1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:
 - a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
 - b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
 - c. Rake grounds that are neither planted nor paved to a smooth, even-textured surface.
 - d. Remove tools, construction equipment, machinery, and surplus material from Project site.
 - e. Remove snow and ice to provide safe access to building.
 - f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
 - g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 - h. Sweep concrete floors broom clean in unoccupied spaces.
 - i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.
 - j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.

- k. Remove labels that are not permanent.
- l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
- m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
- n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
- o. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.
 - 1) Clean HVAC system in compliance with latest NADCA Standards. Provide written report on completion of cleaning.
- p. Clean light fixtures, lamps, globes, and reflectors to function with full efficiency.
- q. Leave Project clean and ready for occupancy.

3.2 REPAIR OF THE WORK

- A. Complete repair and restoration operations before requesting inspection for determination of Substantial Completion.
- B. Repair or remove and replace defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.
 - 1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
 - 2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.
 - a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.
 - 3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.
 - 4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION 017700

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SECTION 01 78 23 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:
 - 1. Operation manuals for systems, subsystems, and equipment.
 - 2. Maintenance manuals for the care and maintenance of products, materials, and finishes systems and equipment.
- B. Related Sections include the following:
 - 1. Division 01 Section "Submittal Procedures" for submitting copies of submittals for operation and maintenance manuals.
 - 2. Divisions 02 through 49 Sections for specific operation and maintenance manual requirements for the Work in those Sections.

1.3 DEFINITIONS

- A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.
- B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 SUBMITTALS

- A. Initial Submittal: Submit 2 draft copies of each manual at least 15 days before requesting inspection for Substantial Completion. Include a complete operation and maintenance directory. Engineer will return one copy of draft and mark when general scope and content of manual are acceptable.
- B. Final Submittal: Submit 3 copies of each manual in final form.

1.5 COORDINATION

- A. Where operation and maintenance documentation includes information on installations by more than one factory-authorized service representative, assemble and coordinate information furnished by representatives and prepare manuals.

PART 2 - PRODUCTS

2.1 MANUALS, GENERAL

- A. Organization: Unless otherwise indicated, organize each manual into a separate section for each system and subsystem, and a separate section for each piece of equipment not part of a system. Each manual shall contain the following materials, in the order listed:
1. Title page.
 2. Table of contents.
 3. Manual contents.
- B. Title Page: Enclose title page in transparent plastic sleeve. Include the following information:
1. Subject matter included in manual.
 2. Name and address of Project.
 3. Name and address of Owner.
 4. Date of submittal.
 5. Name, address, and telephone number of Contractor.
 6. Name and address of Architect.
 7. Cross-reference to related systems in other operation and maintenance manuals.
- C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.
1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.
- D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.
1. Binders: Heavy-duty, 3-ring, vinyl-covered, loose-leaf binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.
 - a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
 - b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents. Indicate volume number for multiple-volume sets.
 2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
 3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software diskettes for computerized electronic equipment.
 4. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.

5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.
 - a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
 - b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

2.2 OPERATION MANUALS

- A. Content: In addition to requirements in this Section, include operation data required in individual Specification Sections and the following information:
 1. System, subsystem, and equipment descriptions.
 2. Performance and design criteria if Contractor is delegated design responsibility.
 3. Operating standards.
 4. Operating procedures.
 5. Operating logs.
 6. Wiring diagrams.
 7. Control diagrams.
 8. Piped system diagrams.
 9. Precautions against improper use.
 10. License requirements including inspection and renewal dates.
- B. Descriptions: Include the following:
 1. Product name and model number.
 2. Manufacturer's name.
 3. Equipment identification with serial number of each component.
 4. Equipment function.
 5. Operating characteristics.
 6. Limiting conditions.
 7. Performance curves.
 8. Engineering data and tests.
 9. Complete nomenclature and number of replacement parts.
- C. Operating Procedures: Include the following, as applicable:
 1. Startup procedures.
 2. Equipment or system break-in procedures.
 3. Routine and normal operating instructions.
 4. Regulation and control procedures.
 5. Instructions on stopping.
 6. Normal shutdown instructions.
 7. Seasonal and weekend operating instructions.
 8. Required sequences for electric or electronic systems.
 9. Special operating instructions and procedures.
- D. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.
- E. Piped Systems: Diagram piping as installed, and identify color-coding where required for identification.

2.3 PRODUCT MAINTENANCE MANUAL

- A. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.
- B. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Product Information: Include the following, as applicable:
 - 1. Product name and model number.
 - 2. Manufacturer's name.
 - 3. Color, pattern, and texture.
 - 4. Material and chemical composition.
 - 5. Reordering information for specially manufactured products.
- D. Maintenance Procedures: Include manufacturer's written recommendations and the following:
 - 1. Inspection procedures.
 - 2. Types of cleaning agents to be used and methods of cleaning.
 - 3. List of cleaning agents and methods of cleaning detrimental to product.
 - 4. Schedule for routine cleaning and maintenance.
 - 5. Repair instructions.
- E. Repair Materials and Sources: Include lists of materials and local sources of materials and related services.
- F. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
 - 1. Include procedures to follow and required notifications for warranty claims.

2.4 SYSTEMS AND EQUIPMENT MAINTENANCE MANUAL

- A. Content: For each system, subsystem, and piece of equipment not part of a system, include source information, manufacturers' maintenance documentation, maintenance procedures, maintenance and service schedules, spare parts list and source information, maintenance service contracts, and warranty and bond information, as described below.
- B. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual.
- C. Manufacturers' Maintenance Documentation: Manufacturers' maintenance documentation including the following information for each component part or piece of equipment:
 - 1. Standard printed maintenance instructions and bulletins.
 - 2. Drawings, diagrams, and instructions required for maintenance, including disassembly and component removal, replacement, and assembly.
 - 3. Identification and nomenclature of parts and components.

4. List of items recommended to be stocked as spare parts.
- D. Maintenance Procedures: Include the following information and items that detail essential maintenance procedures:
1. Test and inspection instructions.
 2. Troubleshooting guide.
 3. Precautions against improper maintenance.
 4. Disassembly; component removal, repair, and replacement; and reassembly instructions.
 5. Aligning, adjusting, and checking instructions.
 6. Demonstration and training videotape, if available.
- E. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.
1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
 2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.
- F. Spare Parts List and Source Information: Include lists of replacement and repair parts, with parts identified and cross-referenced to manufacturers' maintenance documentation and local sources of maintenance materials and related services.
- G. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.
- H. Warranties and Bonds: Include copies of warranties and bonds and lists of circumstances and conditions that would affect validity of warranties or bonds.
1. Include procedures to follow and required notifications for warranty claims.

PART 3 - EXECUTION

3.1 MANUAL PREPARATION

- A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.
- B. Operation and Maintenance Manuals: Assemble a complete set of operation and maintenance data indicating operation and maintenance of each system, subsystem, and piece of equipment not part of a system.
1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
 2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.
- C. Manufacturers' Data: Where manuals contain manufacturers' standard printed data, include only sheets pertinent to product or component installed. Mark each sheet to identify each product or component incorporated into the Work. If data include more than one item in a

tabular format, identify each item using appropriate references from the Contract Documents. Identify data applicable to the Work and delete references to information not applicable.

1. Prepare supplementary text if manufacturers' standard printed data are not available and where the information is necessary for proper operation and maintenance of equipment or systems.
- D. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in Record Drawings to ensure correct illustration of completed installation.
1. Do not use original Project Record Documents as part of operation and maintenance manuals.
 2. Comply with requirements of newly prepared Record Drawings in Division 01 Section "Project Record Documents."
- E. Comply with Division 01 Section "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

END OF SECTION 01 78 23

SECTION 01 78 39 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes administrative and procedural requirements for Project Record Documents and As-Built Documents, including the following:
 - 1. Record Drawings.
 - 2. Record Product Data.
 - 3. As-Built Documents are copies of the Contract Documents kept at the project site used to record deviations on a daily basis. As-Built Documents include Drawings, Project Manual(s), including administrative instructions and technical specifications, Addenda, Change Orders, Field Directives, ASI's, RFI's, and other modifications.
- B. Related Sections include the following:
 - 1. Division 01 Section "Operation and Maintenance Data" for operation and maintenance manual requirements.
 - 2. Divisions 02 through 49 Sections for specific requirements for Project Record Documents of the Work in those Sections.

1.3 SUBMITTALS

- A. Record Drawings: Comply with the following:
 - 1. Number of Copies: Submit one set(s) of marked-up Record Prints and one Electronic Set in color.
 - 2. Number of Copies: Submit copies of Record Drawings as follows:
 - a. Initial Submittal: Submit one set(s) of plots from corrected Record CAD Drawings and one set(s) of marked-up Record Prints. Engineer will initial and date each plot and mark whether general scope of changes, additional information recorded, and quality of drafting are acceptable. Engineer will return plots and prints for organizing into sets, printing, binding, and final submittal.
 - b. Final Submittal: Submit one set(s) of marked-up Record Prints. Print each Drawing, whether or not changes and additional information were recorded. Provide electronic copy of the set in color.
- B. Record Product Data: Submit one copy of each Product Data submittal and one Electronic copy.
 - 1. Where Record Product Data is required as part of operation and maintenance manuals, submit marked-up Product Data as an insert in manual instead of submittal as Record Product Data.

PART 2 - PRODUCTS

2.1 AS-BUILT and RECORD DOCUMENT PREPARATION (Contractor/CM and A/E Joint Responsibility)

1. Contractor/CM shall be responsible for recording daily deviations of construction on a copy of the Conformed Construction Documents kept at the project site. Ultimately, this job-site set known as "As-Built Documents" shall be reviewed by the Architect and incorporated into and become known as "Record Documents".
2. Contractor/CM shall maintain a clean, undamaged set of Conformed Contract Documents (blue or black line prints of drawings and Project Manuals) and ensure they are regularly and promptly marked to show the actual conditions where actual installation, material, equipment or location varies from the Work as shown in the Conformed Documents. All such variations shall be marked on the As-Built Drawings and the As-Built Project Manual(s) at the time of occurrence to ensure accuracy. Mark drawings and pages that are the most capable of showing conditions fully and accurately. Particular attention shall be given to concealed elements that would be difficult to measure and record at a later date. "As-Built Documents" shall be re-viewed by the Architect and Project Manager at Project Meetings, at least monthly to insure they are being kept up to date.
3. Contractor/CM shall submit their As-Built Conformed Contract Documents to the Architect as color scanned PDF files at Substantial Completion.
4. A/E shall promptly review the Contractor/CM's set of marked-up As-Built Conformed Documents for compliance with this Section and shall use them in making revisions to the official Record Documents.
5. Record Documents (Drawings and Project Manual) shall be prepared by the A/E and provided to the OCPS Project Manager prior to the issuance of the Certificate of Final Inspection. The Project shall not be finalized, closed out or a Certificate of Final Inspection issued until the Record Documents have been delivered to OCPS.
RECORD DRAWINGS
6. Record Document Content
 - a. Record Project Manual shall be boldly marked with "RECORD DOCUMENT PROJECT MANUAL" and the revision date.
 - b. Organize Record Documents into manageable, electronic sets, cover sheets, with suitable titles, dates, and other identification (Vol. X of XX, for multiple part sets) noted on the cover of each set. EVERY PAGE of the Record Drawings shall be boldly marked with "RECORD DRAWING" and the revision date.
 - c. Provide significant changes in location and material selections made during the construction process. Include all field changes and document modifications responding to Requests for Information, Architectural Supplemental Instructions and Change Orders.
 - d. Show location of interior and exterior underground utilities and appurtenances, pull boxes, valves, shut offs, dimensionally referenced to permanent and visible surface improvements; final vertical elevations of all underground storm sewer, sanitary, water and gas systems referenced to permanent above ground surfaces; final perimeters and depths of all water retention areas sufficient for the calculation of as-built retention

volume by the Architect. Contractor shall retain and pay for the services of a professionally licensed surveyor to certify elevations, locations, perimeters and depths.

e. State actual manufacturer and model number of equipment installed noted in the Project Manual.

f. Meet with Architect and Project Manager to page-turn (ensure complete/clear information) prior to Record Documents submittal.

- B. As-Built Drawings: Maintain one set of blue- or black-line white prints of the Contract Drawings and Shop Drawings.
1. Preparation: Mark As-Built Drawings to show the actual installation where installation varies from that shown originally. Require individual or entity who obtained record data, whether individual or entity is Installer, subcontractor, or similar entity, to prepare the marked-up Record Prints.
 - a. Give particular attention to information on concealed elements that would be difficult to identify or measure and record later.
 - b. Accurately record information in an understandable drawing technique.
 - c. Record data as soon as possible after obtaining it. Record and check the markup before enclosing concealed installations.
 2. Record Drawings and Project Manuals that have been revised by the A/E to include the site-recorded deviations from the Conformed Documents plus all ASI's, Change Orders, Field Directives and other modifications. Record Drawings shall include the following:
 - a. Dimensional changes to Drawings.
 - b. Revisions to details shown on Drawings.
 - c. Depths of foundations below first floor.
 - d. Locations and depths of underground utilities.
 - e. Revisions to routing of piping and conduits.
 - f. Revisions to electrical circuitry.
 - g. Actual equipment locations.
 - h. Duct size and routing.
 - i. Locations of concealed internal utilities.
 - j. Changes made by Change Order.
 - k. Changes made following Engineer's written orders.
 - l. Details not on the original Contract Drawings.
 - m. Field records for variable and concealed conditions.
 - n. Record information on the Work that is shown only schematically.
 3. Mark the Contract Drawings or Shop Drawings, whichever is most capable of showing actual physical conditions, completely and accurately. If Shop Drawings are marked, show cross-reference on the Contract Drawings.
 4. Mark As-built Drawings with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
 5. Mark important additional information that was either shown schematically or omitted from original Drawings.
 6. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

- C. Format: Identify and date each Record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.
 - 1. Record Drawings: Organize Record Drawings into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.

2.2 RECORD PRODUCT DATA

- A. Preparation: Mark Product Data to indicate the actual product installation where installation varies substantially from that indicated in Product Data submittal.
 - 1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.

2.3 MISCELLANEOUS RECORD SUBMITTALS

- A. Assemble miscellaneous records required by other Specification Sections for miscellaneous record keeping and submittal in connection with actual performance of the Work. Bind or file miscellaneous records and identify each, ready for continued use and reference.

PART 3 - EXECUTION

3.1 RECORDING AND MAINTENANCE

- A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and modifications to Project Record Documents as they occur; do not wait until the end of Project.
- B. Maintenance of Record Documents and Samples: Store Record Documents and Samples in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Project Record Documents for Engineers's reference during normal working hours.

END OF SECTION 01 78 39

SECTION 01 91 13 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. ASHRAE Standard 90.1-2016 and ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.
- C. Commissioning Plan (Cx Plan).
- D. Green Globes for New Construction.

1.2 SUMMARY

- A. Section includes general requirements that apply to implementation of commissioning without regard to specific systems, assemblies, or components.
- B. Commissioning is systematic processes to provide documented confirmation that building systems perform according to the criteria set forth in the design intent and satisfy the owner's operational needs. This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training. The Commissioning process shall comply with ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.
- 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.
- 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.
- E. Abbreviations. The following are common abbreviations used in the *Specifications* and in the *Commissioning Plan*. Definitions are found in Section 1.3.

OPR-	Owner's Project Requirements	HVAC-	Heating, Ventilating and Air Conditioning
CxA-	Commissioning authority	BoD	Basis of Design
CC	Controls contractor	MC-	Mechanical contractor
CM-	Construction Manager at Risk	OR-	Owner's Representative
Cx-	Commissioning	CVC-	Component Verification Checklist

Cx Plan-	Commissioning Plan document	PM-	Project manager (of the Owner)
EC-	Electrical contractor	Subs-	Subcontractors to CM or GC
FPT	Functional performance test	TAB-	Test and Balance contractor
GC	General Contractor		

F. Related Sections:

1. Division 01 Section 01 33 00 - "Submittal Procedures" for additional detail in submittals required for commissioning.
2. Division 01 Section 01 77 00 - "Closeout Procedures" which defines substantial completion and functional completion, relative to commissioning.
3. Division 01 Section 01 40 00 - "Quality Requirements" defines project quality requirements.
4. Division 01 Section 01 78 23 - "Operations and Maintenance Data" defines requirements for commissioning process activities.

1.3 DEFINITIONS

- A. Acceptance Phase. Phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and training occurs.
- B. Approval. Acceptance that a piece of equipment or system has been properly installed and is functioning in the tested modes according to the Contract Documents.
- C. Engineer: The prime consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.
- D. BoD: Basis of Design. A document that records concepts, calculations, decisions, and product selections used to meet the OPR and to satisfy applicable regulatory requirements, standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.
- E. Construction Manager (CM): Construction Manager for this project.
- F. CxA: Commissioning Authority. An independent agent, not otherwise associated with the Engineer team members, the CM or the GC, hired by the Owner. The CxA directs and coordinates the day-to-day commissioning activities. The CxA does not take an oversight role like the CM or GC. The CxA coordinates with the CM and/or the GC, but shall report directly to the Owner.
- G. Cx Plan: Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process
- H. Datalogging: Monitoring flows, currents, status, pressures, etc. of equipment using stand-alone dataloggers separate from the control system.

- I. Deferred Functional Tests : FTs that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.
- J. Deficiency : A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the design intent)
- K. Design Intent: A dynamic document that provides the explanation of the ideas, concepts and criteria that are considered to be very important to the owner. It is initially the outcome of the programming and conceptual design phases.
- L. Design Narrative or Design Documentation: Sections of either the Design Intent or Basis of Design.
- M. Factory Testing: Testing of equipment on-site or at the factory by factory personnel with an Owner's representative present.
- N. Functional Performance Test (FPT) or (FT): Test of the dynamic function and operation of equipment and systems using manual (direct observation) or monitoring methods. Functional testing is the dynamic testing of systems (rather than just components) under full operation (e.g., the chiller pump is tested interactively with the chiller functions to see if the pump ramps up and down to maintain the differential pressure setpoint). Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, fire alarm, power failure, etc. The systems are run through all the control system's sequences of operation and components are verified to be responding as the sequences state. Traditional air or water test and balancing (TAB) is not functional testing, in the commissioning sense of the word. TAB's primary work is setting up the system flows and pressures as specified, while functional testing is verifying that which has already been set up. The commissioning authority develops the functional test procedures in a sequential written form, coordinates, oversees and documents the actual testing, which is usually performed by the installing contractor or vendor. FTs are performed after verification checklists and start-up activities are complete.
- O. General Contractor (GC): Contractor responsible for general work and responsible for coordination of other discipline contractors, including plumbing, mechanical, and electrical.
- P. Green Globes: Green Globes is a web-based program for green building guidance and certification that includes an onsite assessment by a third party. Green Globes offers a way to advance the overall environmental and sustainability of commercial and institutional buildings. The Green Globes ratings / certification system uses an assessment protocol to comprehensively assess environmental impacts in multiple categories, including: Project Management, Site, Energy, Water, Materials and Resources, Emissions and Indoor Environment.
- Q. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed
- R. Manual Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").
- S. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.

- T. Non-Compliance: See Deficiency.
- U. Non-Conformance: See Deficiency.
- V. Over-written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50°F to 75°F to verify economizer operation). See also "Simulated Signal."
- W. OPR: Owner's Project Requirements. 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.
- X. PM: Construction Project Manager. The construction project manager for this project. This person could be either a direct employee of OWNER, or a contract PM from a third-party project management firm contracted to OWNER. The PM works for and represents the owner.
- Y. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.
- Z. Seasonal Performance Tests: FT that are deferred until the system(s) will experience conditions closer to their design conditions.
- AA. Simulated Condition: Condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).
- BB. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.
- CC. Systems, Subsystems, Equipment, and Components: Where these terms are used together or separately, they shall mean "as-built" systems, subsystems, equipment, and components.
- DD. Startup: The initial starting or activating of dynamic equipment, including executing verification checklists.
- EE. Subcontractors (Subs): The subcontractors to the CM (or General Contractor) who provide and install building components and systems.
- FF. Test Procedures: The step-by-step process which must be executed to fulfill the test requirements. The test procedures are developed by the CxA.
- GG. Test Requirements: Requirements specifying what modes and functions, etc. shall be tested. The test requirements are not the detailed test procedures. The test requirements are specified in the Contract Documents
- HH. Trending: Monitoring using the building control system.
- II. Vendor: Supplier of equipment.
- JJ. Component Verification Checklist (CVC): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment, provided by the CxA to the CM (or General Contractor) and the Subcontractors. Component verification checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels proper, labels affixed, gages in place, sensors calibrated, etc.). However, some checklist items entail simple testing of the function of a component, a piece of

equipment or system (such as measuring the voltage imbalance on a three phase pump motor). Component verification checklists augment and are combined with the manufacturer's start-up checklist. Even without a commissioning process, contractors typically perform some, if not many, of the verification checklist items a commissioning authority will recommend. However, few contractors document in writing the execution of these checklist items. Therefore, for most equipment, the contractors execute the checklists on their own. The commissioning authority only requires that the procedures be documented in writing, and does not witness much of the verification checklist, except for larger or more critical pieces of equipment.

- KK. Warranty Period: Warranty period for entire project, including equipment components. Warranty begins at Substantial Completion and extends for at least one year, unless specifically noted otherwise in the Contract Documents and accepted submittals.

1.4 COORDINATION

- A. Commissioning Team. The members of the commissioning team consist of the Commissioning Authority (CxA), the Owner's Representative (OR), the designated representative of the Owner's Construction Management firm (CM), the Architect and Design Engineers (Engineer, particularly the Mechanical Engineer), the General Contractor (GC), the Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB contractor, the Controls Contractor (CC), any other installing subcontractors or suppliers of equipment. If known, the Owner's building or operator/engineer is also a member of the commissioning team.
- B. Management. The CxA is hired by the Owner directly. The CxA directs and coordinates the commissioning activities and the reports to the OR. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Scheduling. The CxA will work with the CM (and/or GC) according to established protocols to schedule the commissioning activities. The CxA will provide sufficient notice to the CM and/or GC for scheduling commissioning activities. The CM and/or GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.
- D. The CxA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The *Commissioning Plan—Construction Phase* provides a format for this schedule. As construction progresses, more detailed schedules are developed by the CxA.

1.5 COMMISSIONING PROCESS

- A. Commissioning Plan. The commissioning plan provides guidance in the execution of the commissioning process. Just after the initial commissioning scoping meeting the CxA will update the plan which is then considered the "final" plan, though it will continue to evolve and expand as the project progresses. The *Specifications* will take precedence over the *Commissioning Plan*.
- B. Commissioning Process. The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.

1. Commissioning during construction begins with a scoping meeting conducted by the CxA where the commissioning process is reviewed with the with the commissioning team members.
2. Additional meetings will be required throughout construction, scheduled by the CxA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.
3. Equipment documentation is submitted to the CxA during normal submittals, including detailed start-up procedures.
4. The CxA works with the CM and/or GC and the Subcontractors in developing start-up plans and start-up documentation formats, including providing the CM and/or GC and the Subcontractors with component verification checklists (CVC) to be completed, prior to the start-up process.
5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with component verification checklists being completed before functional testing.
6. The Subcontractors, under the direction of the CM and/or GC, execute and document the component verification checklists and perform startup and initial checkout. The CxA documents that the CVC and startup were completed according to the approved plans. This may include the CxA witnessing start-up of selected equipment.
7. The CxA develops specific equipment and system Functional Performance test procedures. The OR, the Engineer, the CM and/or the GC and the Subcontractors (particularly the CC) review the test procedures.
8. The procedures are executed by the CM, GC and the Subcontractors, under the direction of, and documented by the CxA.
9. Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.
10. Commissioning is completed before Substantial Completion.
11. When applicable, the CxA, the OR and the Engineer review, pre-approve and coordinate the training provided by the CM and/or the GC and the Subcontractors, and verifies that is was completed.
12. When applicable, the development of systems' manuals will be coordinated by the CM, the GC and CxA with the Owner's O&M personnel, Engineer and Subcontractors. The CM and/or the GC will be responsible to provide the systems manuals, the CxA will review the Systems Manual and add to the manual the gathered Cx documentation.
13. When applicable, the CxA, contractors and OR will perform a building review site visit approximately 10 months into the 12 month warranty period. The CxA will report findings to the OR. The CM and/or the GC will be responsible for issues resolution, along with the appropriate Subcontractors.
14. Deferred testing is conducted, as specified or required.

C. Cloud-based Web Application Software

1. For this project, the Cx Authority will be utilizing a cloud-based web application for managing the commissioning documentation associated with the project. A dedicated project site will be established and this web application will provide real time data and a single interface for all project team members to share information and collaborate effectively.
2. Commissioning documentation will be maintained on this site and secure access will be provided to all team members. Cx documentation will be maintained in an electronic format, with automatic synchronization with the cloud as it is updated. However, provisions will be provided to create PDF versions of select Cx files for printing.

3. Team members will be notified of updates to the site through e-mails on a regular basis (typically daily). Discrete commissioning files will not be e-mailed to the team. This system will require contractors and subcontractors to monitor Cx activities and documentation through the site, and to utilize tablet (or laptop) PCs when completing checklists and addressing issues in the field. Tablets and/or laptop PCs will be the responsibility of the individual team members. Requirements for same (compatible operating systems and browsers) will be provided by the Cx Authority.
4. The Cx Authority will provide initial instruction on the use of this web application and answer questions at a Cx kick-off meeting. All contractors and subcontractors will be expected to have designated representatives from their firms available for training.

1.6 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s): Individuals, each having the authority to act on behalf of the entity he or she represents, explicitly organized to implement the commissioning process through coordinated action. The commissioning team shall consist of, but not be limited to, the Construction Manager (CM), the General Contractor (GC), including Project superintendent and subcontractors, installers, suppliers, and specialists deemed appropriate by the CxA.
- B. Members Appointed by Owner:
 1. CxA: The designated person, company, or entity that plans, schedules, and coordinates the commissioning team to implement the commissioning process. Owner will engage the CxA under a separate contract.
 2. Representatives of the facility user and operation and maintenance personnel.
 3. The Owners Representative.
 4. Architect and Engineering design professionals.

1.7 OWNER'S RESPONSIBILITIES

- A. Assign operation and maintenance personnel and schedule them to participate in commissioning team activities.
- B. Provide the Basis of Design (BoD) documentation, prepared by the Engineer and approved by the Owner, to the CxA for use in developing the: OPR, commissioning specifications, commissioning plan, systems manual (if required), and assist with review of the operation and maintenance manuals and the training plan.
- C. Review the Cx Plan and edit in coordination with project-specific requirements and the CxA. Follow the completed Cx Plan and support the CxA with implementation.
- D. Attend commissioning scoping meetings and additional meetings as necessary.
- E. Manage the contract of the Engineer, the CxA, and the CM and/or the GC.
- F. Provide final approval for the completion of the commissioning work.
- G. Ensure that any seasonal or deferred testing and any deficiency issues are addressed.
- H. Schedule with the CM and/or the GC, the field training sessions according to the Commissioning Plan.

1.8 ENGINEERS' RESPONSIBILITIES

- A. The Engineer shall comply with the fullest extent with the OWNER Design Guidelines in regards to Design maintainability & design for reliability. The Engineer shall participate in and perform commissioning process activities including, but not limited to, the following:
1. Attend the commissioning scoping meeting and selected commissioning team meetings.
 2. Perform normal submittal review and approve of the following documents; submittals, shop drawings, as-built drawing, O&M manual, etc., as contracted.
 3. Provide all design narrative and sequence documentation requested by the CxA. The designers shall assist (along with the CM and/or the GC) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
 4. Coordinate resolution of system deficiencies identified during commissioning, according to the contract documents.
 5. Review and approve final as-built design intent documentation for inclusion in the O&M manuals. Review and approve the O&M manuals issued by the CM and/or GC.
 6. Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.
 7. Participate in the resolution of non-compliance, non-conformance and design deficiencies identified during commissioning during warranty-period commissioning.

1.9 CONSTRUCTION MANAGER at RISK (CM) / GENERAL CONTRACTOR (GC) RESPONSIBILITIES

- A. The CM and/or the GC shall participate in and perform commissioning process activities including, but not limited to the following:
1. Facilitate the coordination of the commissioning work by the CxA, with complete knowledge of commissioning activities which will be incorporated into the master construction project schedule.
 2. Review and approve the final *Commissioning Plan—Construction Phase*.
 3. Attend a commissioning scoping meeting and other commissioning team meetings.
 4. Issue sub-contractor submittals for Engineer approval and CxA review.
 5. Furnish a copy of all construction documents, addenda, requests for information, change orders and approved submittals and shop drawings related to commissioned equipment to the CxA.
 6. Issue O & M manuals to Engineer for approval within 45 days of approved submittals.
 7. Review and approve the Functional Performance test procedures submitted by the CxA, prior to testing.
 8. Review commissioning progress and deficiency reports. Comment on issue resolve.
 9. Coordinate the resolution of non-compliance and design deficiencies identified in all phases of commissioning.
 10. Coordinate with the CxA for resolution of issues recorded in the CxA Issues Log.
 11. Review and accept construction Component verification checklists provided by the CxA.
 12. Complete paper or electronic construction Component verification checklists as work is completed and provide to the CxA. Complete commissioning process test procedures.
 13. Include the cost of coordinating commissioning with the CxA in the total contract price.
 14. Execute seasonal or deferred functional performance testing witnessed by the CxA to facilitate the Cx process.
 15. Provide a list of final settings, setpoints, ranges, schedules, and / or trend logs required by the CxA.
 16. Coordinate with CxA and OR production of systems manuals that will provide future operating staff the information needed to understand and operate the commissioned system.

17. Follow the Commissioning Plan throughout the entire project duration.

1.10 SUB CONTRACTOR'S RESPONSIBILITIES

- A. The CM and/or the GC shall assign representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Include the cost of commissioning in the contract price.
 2. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 3. Assist in equipment testing per agreements with the CM and/or the GC.
 4. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the CM and/or the GC, except for stand-alone data logging equipment that may be used by the CxA.
 5. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
 6. Review test procedures for equipment installed by factory representatives.
 7. Follow the Commissioning Plan.
 8. Attend commissioning scoping meetings and additional meetings as necessary.

1.11 EQUIPMENT SUPPLIERS RESPONSIBILITIES

- A. The CM and/or the GC shall assign the equipment suppliers & representatives with expertise and authority to act on its behalf and shall schedule them to participate in and perform commissioning process activities including, but not limited to, the following:
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Owner to keep warranties in force.
 2. Assist in equipment testing per agreements with the CM and/or the GC and the Subcontractors.
 3. Include all special tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these Contract Documents in the base bid price to the CM and/or the GC, except for stand-alone datalogging equipment that may be used by the CxA.
 4. Through the CM and/or the GC and the Subcontractors, they supply products to, analyze specified products and verify that the designer has specified the newest most updated equipment reasonable for this project's scope and budget.
 5. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.
 6. Review test procedures for equipment installed by factory representatives.
 7. Follow the Commissioning Plan.
 8. Attend commissioning scoping meetings and additional meetings as necessary.

1.12 CxA'S RESPONSIBILITIES

- A. The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving, non-conformance or deficiencies, but ultimately that responsibility resides with the CM, GC, Subs and the Engineer. The primary role of the CxA is to develop and coordinate the execution of a testing plan, observe and document performance

— that systems are functioning in accordance with the documented design intent and in accordance with the Contract Documents. The CM, the GC and the Subcontractors will provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CxA.

1. Coordinates and directs the commissioning activities using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
2. Coordinate the commissioning work and, with the CM, the GC and the Subcontractors, ensure that commissioning activities are being scheduled into the master schedule.
3. Revise, as necessary, the *Commissioning Plan—Construction Phase*.
4. Plan and conduct a commissioning scoping meeting and other commissioning meetings.
5. Request and review additional information required to perform commissioning tasks, including O&M materials, subcontractor start-up and checkout procedures.
6. Before startup, gather and review the current control sequences and interlocks and work with subcontractors and Design Engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
7. Review and comment on normal CM, GC and Subcontractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the Engineer reviews / approvals.
8. Write and distribute component verification checklists.
9. Review the start-up and initial systems checkout plan developed by the CM, GC and the Subcontractors.
10. Perform site visits, as necessary, to observe component and system installations. Attends selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
11. Witness all or part of the HVAC piping test and flushing procedure, sufficient to be confident that proper procedures were followed. Document this testing. Notify owner's representative of any deficiencies in results or procedures.
12. Witness all or part of any ductwork testing and cleaning procedures, sufficient to be confident that proper procedures were followed. Document this testing. Notify owner's representative of any deficiencies in results or procedures.
13. Approve Component Verification Checklist tests and checklist completion by reviewing component verification checklist reports and by selected site observation and spot checking.
14. Approve systems startup by reviewing start-up reports and by selected site observation.
15. Review TAB execution plan.
16. Oversee sufficient functional testing of the control system and approve it to be used for TAB, before TAB is executed.
17. With necessary assistance and review from the CM, GC and installing subcontractors, write the Functional Performance test procedures for equipment and systems. This may include energy management control system trending, stand-alone datalogger monitoring or manual functional testing. Submit to the Engineer, and OR for review and approval.
18. Analyze functional performance trend logs and monitoring data to verify performance.
19. Coordinate, witness and document functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
20. Maintain a master issues (deficiency and resolution) log and a separate testing record. Provide the CM, GC, Subcontractors and OR with written progress reports and test results with recommended actions.
21. When applicable, witness performance testing of smoke control system interfaced with the HVAC systems, by others and all other owner contracted tests or tests by manufacturer's personnel over which the CxA may not have direct control. Document these tests and include this documentation in Commissioning Report.

22. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.
23. Compile and maintain a commissioning record.
24. Provide a final commissioning report to the Owner.
25. Coordinate and supervise required seasonal or deferred testing and deficiency corrections.
26. Return to the completed project site at 10 months into the 12 month warranty period for measurement and verification (M & V) with Owner personnel and review with facility staff the current building operation and the condition is performing in compliance with design intent of the project design and to ensure issues related to the original and seasonal commissioning are still in tact. Also interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract.

1.13 SYSTEMS TO BE COMMISSIONED

- A. Systems to Commission: The specific systems to be commissioned include but are not necessarily limited to:
 1. HVAC and Mechanical
 - a. Building automation systems and linkages to remote monitoring and control sites.
 - b. Graphics, software, firmware, points list, diagnostics, trending, reporting etc.
 - c. Chillers, water pumps, piping, and associated equipment.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the CM, GC and/or Subcontractors for the equipment being tested. For example, the mechanical contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 23, except for equipment specific to and used by TAB in their commissioning responsibilities. Two-way radios shall be provided by the CM and/or the GC.
- B. Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the CM, GC and/or Owner and left on site, except for stand-alone datalogging equipment that may be used by the CxA.
- C. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances required. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.
- D. Refer to Section 019113, Part 3.5 E for details regarding equipment that may be required to simulate required test conditions.

PART 3 - EXECUTION

3.1 MEETINGS

- A. Scoping Meeting - The CxA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CxA. Information gathered from this meeting will allow the CxA to revise the *Commissioning Plan* to its "final" version, which will also be distributed to all parties.
- B. Miscellaneous Meetings - Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution and planning issues with the CM, GC and the Subcontractors. The CxA will plan these meetings and will minimize unnecessary time being spent by the CM, the GC and the Subcontractors.

3.2 REPORTING

- A. The CxA will provide regular reports to the CM, the GC and the OR, with increasing frequency as construction and commissioning progresses.
- B. The CxA will regularly communicate with members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
- C. Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.
- D. A final summary report by the CxA will be provided to the CM, the GC and the OR, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report.

3.3 SUBMITTALS

- A. The CxA will provide appropriate contractors with a specific request for the type of submittal documentation the CxA will require to facilitate the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All documentation requested by the CxA will be included by the Subcontractors in their O&M manual contributions.
- B. The Commissioning authority will review and provide comment on submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the CM, the GC, the Owner

Representative, and/or the Engineer as requested, of items missing or areas that are not in conformance with Contract Documents and which require resubmission.

- C. The CxA may request additional design narrative from the Engineer and the Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.
- D. These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the CM, the GC and the Subcontractors.
- E. The CM's, GC's and/or Subcontractor's responsibility for deviations in submittals from requirements of the Contract Documents is not relieved by the Commissioning Authority's review.

3.4 START-UP, COMPONENT VERIFICATION CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.14, Systems to be Commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified CVCs and start-up.
- B. General. Component verification checklists are important to ensure that the equipment and systems are connected and operational. These checklists help confirm that Functional Performance Testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- C. Start-up and Initial Checkout Plan. The CxA may assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for component verification checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. The CM, GC, subcontractors and manufacturer's technicians shall be responsible for executing Functional Performance Tests for their representative equipment and systems.
 - 1. The CxA develops the component verification checklists for all equipment and/or systems to be commissioned and delivers the CVCs to the CM, GC and Subcontractors for completion. These CVCs indicate required procedures to be executed as part of start-up and initial checkout of the systems and the party responsible for their execution.
 - 2. These CVCs and tests are provided by the CxA to the CM and/or GC. The CM and/or GC determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.
 - 3. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan. The full start-up plan could consist of something as simple as:
 - a. The CxA's Component Verification Checklists.

- b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
 - c. The manufacturer's normally used field checkout sheets.
 4. The subcontractor submits the full start-up plan to the CM and/or GC and the CxA for review and approval.
 5. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.
 6. The full start-up procedures and the approval form may be provided to the CM and/or GC for review and approval, depending on management protocol.
 - D. Sensor and Actuator Calibration.
 1. All field-installed temperature, relative humidity, CO₂ and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if approved by the Owner before-hand. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.
 2. All procedures used shall be fully documented on the component verification checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.
 3. Sensor Calibration Methods.
 - a. All Sensors. Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure. Tolerances for critical applications may be tighter.
 - b. Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.
 - c. Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.
 - d. Critical Applications. For critical applications (process, manufacturing, etc.) more rigorous calibration techniques may be required for selected sensors. Describe any such methods used on an attached sheet.

Tolerances, Standard Applications

<u>Sensor</u>	<u>Required Tolerance (+/-)</u>	<u>Sensor</u>	<u>Required Tolerance(+/-)</u>
Cooling coil, chilled water temps	0.4°F	Flow rates, water	4% of design
AHU wet bulb or dew point	2.0°F	Relative Humidity	4% of design
Hot water coil, water temp	1.5°F	Oxygen or CO ₂ monitor	0.1 % pts
Outdoor air, space air, duct air temps	0.4°F	Flow rates, air	10% of design
Watt-hour, voltage & amperage	1% of design	Barometric pressure	0.1 in. of Hg
Pressures, air, water	3% of design		

4. Valve and Damper Stroke Setup and Check.

- a. BAS Readout. For all valve and damper actuator positions checked, verify the actual position against the BAS readout.
- b. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

E. Execution of Component Verification Checklists and Startup.

1. Four weeks prior to start-up, the CM, the GC and the Subcontractors and vendors schedule start-up and checkout with the CxA. The performance of the component verification checklists, start-up and checkout are directed and executed by the CM, the GC, and the Subcontractors or vendor. When checking off verification checklists, signatures may be required by the CM, the GC and/or their Subcontractors for verification of completion of their work.
2. The CxA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the CxA and the OR). In no case will the number of units witnessed be less than four, nor less than 20% of the total number of identical or very similar units.
3. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.
4. The CM, the GC, and the Subcontractors and vendors shall execute start-up and provide the CxA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
5. Only individuals that have direct knowledge and witnessed that a line item task on the verification (prefunctional) checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

F. Deficiencies, Non-Conformance and Approval in Checklists and Start-up.

1. The CM, the GC and the Subcontractors shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CxA within two days of test completion.
2. The CxA shall work with the CM, the GC and the Subcontractors and vendors to correct and retest deficiencies or uncompleted items. The CxA will involve the CM, the GC and

the Subcontractors, as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CM, the GC and the CxA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CxA recommends approval of the execution of the checklists and start-up of each system to the OR using a standard form.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back charges to the responsible party. Refer to Part 3.6 herein for details.

3.5 FUNCTIONAL PERFORMANCE TESTING

- A. This sub-section applies to all commissioning functional testing for all divisions.
- B. The general list of equipment to be commissioned is found in Section 019113, Part 1.14. The specific system Functional Performance Tests (with required modes and sequences to be tested) will be developed after complete review of the control shop drawings and discussion with the Engineer-of-Record.
- C. The parties responsible to execute each test are the CM's and/or GC's installing subcontractors and associated vendors, manufacturer's representatives and technicians.
- D. Objectives and Scope. The objective of Functional Performance Testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
 1. In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, no flow, equipment failure, etc. may also be tested.
 2. Development of Test Procedures. Before test procedures are written, the CxA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CxA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. The CM's and/or GC's Subcontractor or vendor responsible to execute a test shall provide assistance to the CxA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CxA shall provide a copy of the test procedures to the CM, the GC, the CC and the Subcontractors who shall review the tests for feasibility, safety, equipment and warranty protection. The CxA will submit the tests to the Engineer and the OR for review.
 3. The CxA shall review owner-contracted, factory testing or required owner acceptance tests, which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.
 4. The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

5. The test procedure forms developed by the CxA shall include (but not be limited to) the following information:
 - a. System and equipment or component name(s)
 - b. Equipment location and ID number
 - c. Unique test ID number, and reference to unique component verification checklist and start-up documentation ID numbers for the piece of equipment
 - d. Date
 - e. Project name
 - f. Participating parties
 - g. A copy of the specification section describing the test requirements
 - h. A copy of the specific sequence of operations or other specified parameters being verified
 - i. Formulas used in any calculations
 - j. Required pre-test field measurements
 - k. Instructions for setting up the test.
 - l. Special cautions, alarm limits, etc.
 - m. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
 - n. Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
 - o. A section for comments
 - p. Signatures and date block for the CxA

E. Test Methods

1. Functional Performance Testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers. The final Functional Performance Test protocols, as developed by the CxA, shall specify which methods shall be used for each test. The CxA may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the OR and the CM or GC. This may require a change order and adjustment in charge to the Owner. The CxA will determine which method is most appropriate for tests that do not have a method specified.
2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
3. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.
5. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AHU lockout work at an outside air temperature below 55°F, when the outside air temperature is above 55°F, temporarily change the lockout setpoint to be 2°F above the current outside air temperature.

6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.
 7. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Subcontractor executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Subcontractor shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
 8. Sampling. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. 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. The specific recommended sampling rates for each type of equipment will be dictated by the CxA. It is noted that no sampling by the CM's or the GC's Subcontractors is allowed in component verification checklist execution.
- F. Coordination and Scheduling. The CM, the GC and the Subcontractors shall provide sufficient notice to the CxA regarding their completion schedule for the verification checklists and startup of all equipment and systems. The CxA will schedule Functional Performance Tests through the CM, the GC and the Subcontractors. The CxA shall direct, witness and document the Functional Performance Tests of all equipment and systems. The CM, the GC, and the Subcontractors shall execute the tests.
1. In general, Functional Performance Testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CxA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.
- G. Test Equipment. Refer to Section 019113, Part 2 for test equipment requirements.
- H. Problem Solving. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, the GC, the Subcontractors and the Engineer.
- 3.6 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS
- A. Documentation. The CxA shall witness and document the results of all Functional Performance Tests (FPT) using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the CM, the GC and the CC for review and approval. The CM and/or the GC shall issue the final FPTs to the Subs for execution. The CxA will include the completed and executed forms in the final Cx report.
 - B. Non-Conformance.
 1. The CxA will record the results of the Functional Performance Test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the

- CM, the GC and the Subs on the Master Issues Log and/or a standard non-compliance form.
2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.
 3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the Owner's Representative.
 4. As tests progress, deficiencies are identified, the CxA discusses the issues with the CM, the GC and the appropriate Subcontractor(s).
 - a. When there is no dispute on the deficiency and the CM, the GC, and the Subcontractor accepts responsibility to correct it:
 - 1) The CxA documents deficiencies on the project Master Issues Log which will be updated as the testing progresses.
 - 2) The CxA reschedules the test and the test is repeated.
 - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1) The CxA documents deficiencies on the project Master Issues Log which will be updated as the testing progresses.
 - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the Engineer and the OR. Final acceptance authority is with the Owner's Project Manager.
 - 3) The CxA documents the resolution process on the issues log.
 - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency. The CxA reschedules the test and the test is repeated until satisfactory performance is achieved.
 5. Cost of Retesting.
 - a. The cost for the *Sub* to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the CM and/or the GC.
 - b. For a deficiency identified, not related to any verification checklist or start-up fault, the following shall apply: The CxA and CM and/or the GC will direct the retesting of the equipment once at no "charge" to the Subcontractors for their time. However, the CxA's, CM's and GC's time for a second retest will be charged to the Subcontractors.
 - c. The time for the CxA, the CM and/or the GC to direct any retesting required because a specific *verification* checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the Subcontractors.
 6. The CM, the GC, and the Subcontractors shall respond in writing to the CxA at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
 7. Any required retesting by any subcontractor shall not be considered a justified reason for a claim of delay or for a time extension by the CM and/or the GC.
- C. Failure Due to Manufacturer Defect. If 10%, or three, whichever is greater, of identical pieces of equipment (size alone does not constitute a difference) fail to perform to the Contract

Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CM, the GC, or the OR. In such case, the CM and/or the GC shall provide the Owner with the following:

1. Within one week of notification from the CM, the GC or the OR, the subcontractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CM, the GC or the OR within two weeks of the original notice.
 2. Within two weeks of the original notification, the subcontractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
 3. The CM, the GC, or the OR will determine whether a replacement of all identical units or a repair is acceptable.
 4. Two examples of the proposed solution will be installed by the subcontractor and the CM and/or the GC will be allowed to test the installations for up to one week, upon which the CM, the GC or the OR will decide whether to accept the solution.
 5. Upon acceptance, the subcontractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.
- D. Approval. The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the Functional Performance Test is made later after review by the CxA and by the CM, the GC, and the OR. The CxA recommends acceptance of each test to the CM, the GC and the OR using a standard form.

3.7 DEFERRED TESTING

- A. Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the OR. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

3.8 WRITTEN WORK PRODUCTS

- A. The commissioning process generates a number of written work products described in various parts of the *Specifications*. In summary, the written products are:

<u>Product</u>	<u>Developed By</u>
1. Develop and maintain a commissioning plan	CxA
2. Issue Cx Specifications	CxA
3. Commissioning milestones coordinated into construction schedule.	CxA with CM and/or GC
4. Equipment documentation submittals	CM, GC and Subcontractors
5. Sequence of Operation clarifications	CM, GC, Subcontractors and Engineer, as needed
5. Develop Component verification checklists	CxA
6. Start-up and initial checkout plan	CM and/or GC, Subs and CxA
7. Start-up and executed Verification Checklists	CM and/or GC and Subcontractors

- | | |
|--|---|
| 8. Final TAB report | with witness of CxA and OR |
| 9. Develop Cx Issues log (deficiencies) | TAB |
| 10. Commissioning Progress Record | CxA |
| 11. Cx Deficiency reports | CxA |
| 12. Develop Functional Performance tests | CxA |
| 13. Execute the functional performance tests | CxA with CM and/or GC and Subs,
TAB contractor, Engineer, and OR |
| 14. Issue O&M manuals for approval / review | CM and/or GC and Subcontractors |
| 15. Issue approved O & M manuals | CM and/or GC and Subcontractors |
| 16. Overall training plan | CM and/or GC and Subcontractors |
| 17. Execute specific training | CM and/or GC and Subs with Mfrs.
Factory Representatives |
| 18. Final commissioning report | CM and/or GC and Subcontractors
CxA |

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SECTION 03 30 00 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section specifies interior and exterior cast-in-place concrete, mix design, placement procedures, and finishes. Work includes, but is not necessarily limited to:
 - 1. Exterior Concrete:
 - a. Equipment pads.
 - 2. Other Materials
 - a. Concrete admixtures
 - b. Concrete floor sealer
- B. The following is by other Sections, meeting the requirements of this Section (unless indicated otherwise).
 - 1. Bases for exterior equipment.
 - 2. Encasement of underground utilities or connections.
 - 3. Specifically excluded items.

1.3 SUBMITTALS

- A. Product data for proprietary materials and items, including reinforcement and forming accessories, admixtures, curing compounds, dry-shake finish materials, hardeners, sealers, and other specified items.
- B. Samples of materials as requested by Architect, including names, sources, and descriptions, as follows:
 - 1. Normal weight aggregates.
 - 2. Reglets.
 - 3.
- C. Laboratory test reports for concrete materials and mix design tests.
- D. Material certificates in lieu of material laboratory test reports when permitted by Architect. Material certificates shall be signed by manufacturer and Contractor, certifying that each material item complies with or exceeds specified requirements. Provide certification from admixture manufacturers that chloride content complies with specification requirements.
- E. Construction Joints: Submit drawing of proposed construction joints in concrete for slabs on grade.
- F. Submit proposed mix designs.
- H. Submit statement from ready-mixed plant verifying conformance to specifications and proposed

mix designs.

- I. Submit concrete curing materials product data and specification sheets.
- J. Submit written approval/ certification of concrete curing materials as specified herein.
- K. Submit ISO 9001/ 9002 Registration Certificate for companies that are ISO registered.

1.4 QUALITY ASSURANCE

- A. Codes and Standards: Comply with the current accepted provisions of the following codes, specifications, and standards, except as otherwise shown or specified.
 - 1. ACI 117 "Specifications for Tolerances for Concrete Construction and Materials."
 - 2. ACI 211.1 "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete."
 - 3. ACI 301 "Specifications for Structural Concrete."
 - 4. ACI 302.1R "Guide for Concrete Floor and Slab Construction."
 - 5. ACI 304R "Guide for Measuring, Mixing, Transporting, and Placing Concrete."
 - 6. ACI 311.4R "Guide for Concrete Inspection."
 - 7. ACI 318, 318R "Building Code Requirements for Reinforced Concrete and Commentary."
 - 8. Concrete Reinforcing Steel Institute, "Manual of Standard Practice."
 - 9. Comply with building code requirements which are more stringent than the above.
 - 10. ACI 305 - "Hot Weather Concreting."
 - 11. ACI 306 - "Cold Weather Concreting."
- B. Document Conflict and Precedence: In case of conflict among Contract Documents, including architectural and structural drawings and specifications, notify the Architect prior to submitting proposal. In case of conflict between and/or among the structural drawings and specifications, the strictest interpretation shall govern, unless specified otherwise in writing by the Architect.
- C. Inspection and Testing of the Work: Materials and installed work may require testing and retesting, as directed by the Architect, at any time during progress of work. Allow free access to material stockpiles and facilities. Tests, not specifically indicated to be done at the Owner's expense, including retesting of rejected materials and installed work, shall be done at the Contractor's expense. Inspection or testing by the Owner does not relieve the Contractor of his responsibility to perform the Work in accordance with the Contract Documents.

1.5 FIELD QUALITY CONTROL

1.7 CONCRETE MATERIALS AND MIX DESIGN

- A. Concrete Materials and Mix Design:
 - 1. Ready-mixed concrete shall be mixed and delivered in accordance with ASTM C94.
 - 2. Product Data: Submit 2 copies of manufacturer's specifications with application an installation instructions for proprietary materials and items, including admixtures, bonding agents, waterstops, joint systems, chemical floor hardeners, and dry shake finish materials.
 - 3. Laboratory Test Reports: Submit 2 copies of laboratory test reports for concrete materials and mix design tests. The Architect's review will be for general information only. Production of concrete to comply with specified requirements is the Contractor's responsibility.
- B. Tests for Concrete Materials
 - 1. For normal weight concrete test aggregates by the methods of sampling and testing of

2. ASTM C33.
For light weight concrete, test aggregates by the methods of sampling and testing of ASTM C330.
 3. For portland cement, sample the cement and determine the properties by the methods of test ASTM C33.
 4. Submit written reports for each material sampled and tested, prior to the start of Work. Provide the project identification name and number, date of report, name of Contractor, name of concrete testing service, source of concrete aggregates material manufacturer and brand name for manufactured materials, values specified in the referenced specification for each material, and test results. Indicate whether or not material is acceptable for intended use.
- C. Submit signed statement from ready-mix plant that concrete furnished for the Project will exactly conform to the approved design mixes.

1.8 PROJECT CONDITIONS

- A. Trades requiring inserts and sleeves for their work shall furnish same for installation as Work under this Section. Delivery of inserts and sleeves for installation as Work under this Section shall be timed so as not to cause delay in the progress of this Work.
- B. Installation requirements within this Specification Section are not intended to be restrictive and the Contractor is allowed when reviewed with the Architect's field representative to adjust the means and methods used to meet required tolerances.

PART 2 - PRODUCTS

2.1 CONCRETE MATERIALS

- A. Portland Cement: ASTM C 150, Type II. Use one brand of cement throughout Project.
- B. Normal-Weight Aggregates: ASTM C33 and as specified. Provide aggregates from a single source for exposed concrete.
 1. For exposed exterior surfaces, do not use fine or coarse aggregates that contain substances that cause spalling.
 2. Local aggregates not complying with ASTM C33 that have been shown to produce concrete of adequate strength and durability by special tests or actual service may be used when acceptable to Architect.
 3. Fine Aggregate: Clean, sharp, natural sand free from loam, clay lumps, or other deleterious substances.
 4. Coarse Aggregate: Clean, uncoated, processed aggregate containing no clay, mud, loam, or foreign matter, as follows:
 - a. Crushed stone, processed from natural rock or stone.
 - b. Washed gravel, either natural or crushed. Use of pit or bankrun gravels not permitted.
 - c. Maximum Aggregate Size: Not larger than one-fifth of narrowest dimension between sides of forms, one-third of depth of slabs, nor three-fourths of minimum clear spacing between individual reinforcing bars or bundles of bars.
 5. Aggregate Supply: Provide aggregates from one source of supply to ensure uniformity in color, size, and shape.

C. Lightweight Aggregates: ASTM C330.

D. Water: Potable.

2.2 PROPORTIONING AND DESIGN MIXES

A. Proportion mixes by either laboratory trial batch or field experience methods as specified in ACI 301, using materials to be employed on the project for each class of concrete required.

B. Submit written reports to Architect of each proposed mix for each type of concrete at least 15 days prior to start of Work. Indicate with each mix design the items or structures for which it is to be used. Do not begin concrete production until mixes have been reviewed by Architect. Submit the following information:

1. Complete identification of aggregate source of supply.
2. Tests of aggregate for compliance with specified requirements.
3. Scale weight of each aggregate.
4. Absorbed water in each aggregate.
5. Brand, type, and composition of cement.
6. Brand, type, and amount of each mixture.
7. Amounts of water used in trial mixes.
8. Proportions of each material per cu.yd. including fibrous secondary reinforcement.
9. Gross weight and yield per cu.yd. of trial mixtures.
10. Measured slump.
11. Measured air content.
12. Compressive strength developed at 7 days and 28 days, from not less than 4 test cylinders cast for each 7 and 28 day test, and for each design mix. These test reports may be from previous projects within the past 6 months.
13. Identification number or name of mix to verify agreement with compression test reports.
14. ACI 318 Proportioning method used.
15. Water cement ratio.
16. Fly ash or pozzolan type and brand.
17. Method by which concrete is intended to be placed.
18. Structural component for which concrete mix is designed.

C. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, at no additional cost to Owner and as accepted by Architect. Laboratory test data for revised mix designs and strength results must be submitted to and accepted by Architect before using in work.

D. Concrete Suppliers Record of Quality Control: The concrete supplier's past record of quality control shall be used in the design of the concrete mixes to determine the amount by which the average concrete strength for should exceed the specified strength $f'c$ as outlined in ACI 318. If a suitable record of test results is not available, the average strength must exceed the design strength by the amount as specified in ACI 318. After sufficient data becomes available from the job, the statistical methods of ACI 214 may be used to reduce the amount by which the average strength must exceed $f'c$ as outlined in ACI 318.

E. Adjustments of Concrete Mixes: Mix design adjustments may be requested by the Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant. Such mix design adjustments shall be provided at no additional cost to the Owner. Any adjustments in approved mix designs including changes in admixtures shall be submitted in writing on the specified Concrete Mix Design Submittal Form to the Architect/Engineer, and Owner's Testing Laboratory for approval prior to field use.

- H. Shrinkage: All concrete shall be proportioned for a maximum allowable unit shrinkage of 0.03% measured at 28 days after curing in lime water as determined by ASTM C157 (using air storage).

2.3 RELATED MATERIALS

- A. Rubber Waterstops: Corps of Engineers CRD-C 513.

1. Manufacturers: Subject to compliance with requirements, provide products of one of the following:
 - a. The Burke Co.
 - b. Progress Unlimited.
 - c. Williams Products, Inc.

- B. Non-Shrink Grout

1. Type: Grout for base plates and bearing plates shall be a non-metallic, shrinkage resistant, premixed, non-corrosive, non-staining product containing Portland cement, silica sand, shrinkage compensating agents and fluidity improving compounds.
2. Specifications: Non-shrink grout shall conform to Corps of Engineers Specification for Non-Shrink Grout, CE-CRD-C621.
3. Compressive Strength: 28 day compressive strength as determined by grout cube tests, shall be as follows:
 - a. 6,000 psi for supporting concrete 3,000 psi and less.
 - b. 8,000 psi for supporting concrete greater than 3,000 psi and less than or equal to 4,000 psi.
 - c. 10,000 psi for supporting concrete greater than 4,000 psi.
4. Products: Acceptable manufacturers as follows:
 - a. "Supreme"; Cormix, Inc.
 - b. "Crystex"; L & M Construction Chemicals, Inc.
 - c. "Masterflow 713"; Master Builders.
 - d. "Five Star Grout"; U.S. Grout Corp.
 - e. "SonogROUT"; Sonneborn Construction Chemicals.
 - f. "Euco-NS"; Euclid Chemical Company
 - g. "Sure-Grip Grout"; Dayton Superior Corp.
5. Manufacturers: At the start of grouting operations, the Contractor shall have a manufacturer's representative observe the grouting operation to insure conformance to requirements.

2.4 CONCRETE CURING MATERIALS

- A. Moisture-Retaining Cover: One of the following, complying with ASTM C171, for concrete floors that are to be exposed or to receive floor sealer.
1. Waterproof paper.
 2. Polyethylene film.
 3. Polyethylene-coated burlap.
- B. Water Based Acrylic Liquid Membrane-Forming Curing Compound: Liquid-type membrane-forming curing compound complying with ASTM C309, Type I, Class B, with 18 to 20

percent minimum solids.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Safe Cure and Seal, Dayton Superior Corp.
- b. Aqua-Cure, Euclid Chemical Co.
- c. Masterseal-W100, Master Builders, Inc.
- d. Vocomp 20, W.R. Meadows, Inc.
- e. Kure-N-Seal, WB, Sonneborn-Chemrex.

C. Evaporation Control: Monomolecular film-forming compound applied to exposed concrete slab surfaces for temporary protection from rapid moisture loss.

1. Products: Subject to compliance with requirements, provide one of the following:

- a. Eucobar, Euclid Chemical Co.
- b. E-Con, L&M Construction Chemicals, Inc.
- c. Confilm, Master Builders, Inc.

D. Coordinate curing methods and requirements with the manufacturer of the floor finish materials and adhesives used to install the floor finish materials. Do not use any curing methods which will inhibit the adhesion and proper installation of the specified floor finish materials.

2.5 BONDING AGENT

A. Chemical Bonding Agent: Film-forming, freeze-thaw resistant compound suitable for brush or spray application complying with MIL-B-19235. Subject to compliance with requirements, provide one of the following:

1. Adbond (J40); Dayton Superior Corp.
2. Euroweld; Euclid Chemical
3. Everbond; L & M Construction Chemicals
4. Sonocrete PB; Sonneborn Building Products
5. Intralok; W.R. Meadows, Inc.

2.6 CONCRETE FLOOR SEALER - EXTERIOR

A. One of the following for exterior second floor walkways and stairs:

1. "Kure-N-Seal 30": Sonneborn Building Products
2. Equal product by L & M Construction Chemicals, Inc.
3. Equal product by Dayton Superior Corp.
4. Color: clear.

2.7 PROPORTIONING AND DESIGNING MIXES

A. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to Architect for preparing and reporting proposed mix designs. Water to cement ratio shall be in the range in a range of 0.4 to 0.5.

1. Do not use the same testing agency for field quality control testing.

B. Submit written reports to Architect of each proposed mix for each class of concrete at least 15 days prior to start of Work. Do not begin concrete production until proposed mix designs have been reviewed by Architect.

- C. Design mixes to provide normal weight concrete with properties as indicated on plans.
- D. Adjustment to Concrete Mixes: Mix design adjustments may be requested by Contractor when characteristics of materials, job conditions, weather, test results, or other circumstances warrant, as accepted by Architect. Laboratory test data for revised mix design and strength results must be submitted to and accepted by Architect before using in Work.

2.8 ADMIXTURES

- A. Use air-entraining admixture in exterior concrete, unless otherwise indicated. Add air-entraining admixture at the manufacturer's prescribed rate to result in concrete at the point of placement having air content within the following limits:
 - 1. Concrete structures and slabs exposed to freezing and thawing or subjected to hydraulic pressure:
 - a. 3 to 15 percent for maximum 2 inches aggregate.
 - b. 4-1/2 percent to 6-1/2 percent for maximum 1 inch aggregate.
 - c. 5 to 7 percent for maximum 3/4 inch aggregate.
 - d. 6 to 8 percent for maximum 1/2 inch aggregate.
 - 2. Other Exterior Concrete: 2 to 4 percent
- B. Use of admixtures for water-reducing and set-control shall be permitted only with prior approval of the Architect for each condition and shall be in strict compliance with the manufacturer's directions.
 - 1. Design mix submittals shall include these admixtures and shall indicate for which types of concrete structures they are to be used.
- C. Use amount of admixtures recommended by manufacturer for climatic conditions prevailing at time of placing. Adjust quantities and types of admixtures as required to maintain quality control.
- D. Use of calcium chloride will not be permitted.

2.9 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements of ASTM C 94, and as specified.
 - 1. When air temperature is between 85 deg F (30 deg C) and 95 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes, and when air temperature is above 95 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
 - 2. Delete the references for allowing additional water to be added to the batch for material with sufficient slump. Addition of water to the batch will not be permitted.
 - 3. During hot weather or under conditions contributing to rapid setting of concrete, a shorter mixing time than specified in ASTM C94 may be required.

PART 3 - EXECUTION

3.1 GENERAL

- A. Coordinate the installation of joint materials, construction joints, vapor retarder/barrier, and other related materials with placement of forms and reinforcing steel.

3.2 PREPARATION

- A. Pre-placement Inspection: Before placing concrete, inspect and complete the formwork installation, reinforcing steel, and items to be embedded or cast-in. Notify other crafts to permit the installation of their work; cooperate with other trades in setting such work, as required.
 - 1. Inspect soil at bottom of foundation systems which will be subject to testing for soil bearing value by the testing laboratory, as directed by the Architect. Place concrete immediately after approval of foundation excavations.
 - 2. Inspect underslab areas that were subject to testing for soil bearing value by the testing laboratory as required by Architect. Place concrete immediately after approval of underslab compaction tests.
- B. Material placement for interior slabs on grade and exterior concrete stoops.
 - 1. Under remaining building slabs, place vapor barrier, lapping joints and 6 inches minimum and seal with tape or mastic, lap and fold joints and turn membrane up on walls to top of floor on existing subgrade. Do not puncture membrane.
 - 2. Install and properly anchor the slab reinforcing mesh.
 - 3. Position waterstops and expansion joint fillers where indicated on the Drawings and as recommended by manufacturer. Special precautions shall be taken to avoid collapse during installation.

3.3 INSTALLING EMBEDDED ITEMS

- A. General: Set and build into formwork anchorage devices and other embedded items required for other work that is attached to or supported by cast-in-place concrete. Use setting drawings, diagrams, instructions, and directions provided by suppliers of items to be attached.
- B. Install dovetail anchor slots in concrete structures.
- C. Forms for Slabs: Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and contours in finished surfaces. Provide and secure units to support screed strips using strike-off templates or compacting-type screeds.

3.4 PREPARING FORM SURFACES

- A. General: Coat contact surfaces of forms with an approved, non-residual, low-VOC, form-coating compound before placing reinforcement.
- B. Do not allow excess form-coating material to accumulate in forms or come into contact with in-place concrete surfaces against which fresh concrete will be placed. Apply according to manufacturer's instructions.
 - 1. Coat steel forms with a non-staining, rust-preventative material. Rust-stained steel formwork is not acceptable.

3.4 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcing steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. General: Comply with ACI 304, "Guide for Measuring, Mixing, Transporting, and Placing Concrete," and as specified.

- C. Deposit concrete continuously or in layers of such thickness that no new concrete will be placed on concrete that has hardened sufficiently to cause seams or planes of weakness. If a section cannot be placed continuously, provide construction joints as specified. Deposit concrete to avoid segregation at its final location. Concreting should be placed at such a rate that the concrete is at all times plastic.
- D. Placing Concrete in Forms: Deposit concrete in forms in horizontal layers no deeper than 24 inches and in a manner to avoid inclined construction joints. Where placement consists of several layers, place each layer while preceding layer is still plastic to avoid cold joints.
1. Consolidate placed concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures for consolidation of concrete complying with ACI 309.
 2. Do not use vibrators to transport concrete inside forms. Insert and withdraw vibrators vertically at uniformly spaced locations no farther than the visible effectiveness of the machine. Place vibrators to rapidly penetrate placed layer and at least 6 inches into preceding layer. Do not insert vibrators into lower layers of concrete that have begun to set. At each insertion, limit duration of vibration to time necessary to consolidate concrete and complete embedment of reinforcement and other embedded items without causing mix to segregate.
- E. Placing Concrete Slabs: Deposit and consolidate concrete slabs in a continuous operation, within limits of construction joints, until completing placement of a panel or section.
1. Consolidate concrete during placement operations so that concrete is thoroughly worked around reinforcement, other embedded items and into corners.
 2. Bring slab surfaces to correct level with a straightedge and strike off. Use bull floats or darbies to smooth surface free of humps or hollows. Do not disturb slab surfaces prior to beginning finishing operations.
 3. Maintain reinforcing in proper position on chairs during concrete placement.
- F. Hot-Weather Placement: When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305 and as specified.
1. Cool ingredients before mixing to maintain concrete temperature at time of placement to below 95 deg F. (35 deg C). Mixing water may be chilled or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
 2. Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.
 3. Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.
 4. Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to Architect.
- G. The following concrete shall be prohibited:
1. Partially hardened concrete.
 2. Contaminated concrete.
 3. Re-tempered concrete.
 4. Concrete that has been re-mixed after it has taken its initial set.

3.5 MONOLITHIC SLAB FINISHES

- A. General Information (Slabs on Grade): The requirements indicated are based upon the latest FF/FL method. Bids for this work shall reflect these requirements and enforcement thereof can be expected.
- B. Float Finish - Not Critical Floor Tolerance: Apply float finish to monolithic slab surfaces that are to receive trowel finish and other thick finishes as hereinafter specified, and slab surfaces which are to be covered with waterproofing membrane or sand-bed terrazzo, and as otherwise shown on Drawings or in Schedules.

3.6 MISCELLANEOUS CONCRETE ITEMS

- A. Filling In: Fill in holes and openings left in concrete structures for passage of work by other trades, unless otherwise shown or directed, after work of other trades is in place. Mix, place, and cure concrete as specified to blend with in-place construction. Provide other miscellaneous concrete filling shown or required to complete Work.
- B. Curbs: Provide monolithic finish to interior curbs by stripping forms while concrete is still green and by steel-troweling surfaces to a hard, dense finish with corners, intersections, and terminations slightly rounded.
- C. Equipment Bases and Foundations: Provide machine and equipment bases and foundations. Set anchor bolts for machines and equipment to template at correct elevations, complying with diagrams or templates of manufacturer furnishing machines and equipment.
- D. Grout base plates as indicated, using specified non-metallic, non-shrink grout.

3.7 CONCRETE CURING AND PROTECTION

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. In hot, dry, and windy weather protect concrete from rapid moisture loss before and during finishing operations with an evaporation-control material. Apply according to manufacturer's instructions after screeding and bull floating, but before power floating and trawling.
- B. Start initial curing as soon as free water has disappeared from concrete surface after placing and finishing. Weather permitting; keep continuously moist for not less than 72 hours.
- C. Curing Methods: Cure concrete by curing compound, by moist curing, by moisture-retaining cover curing, or by combining these methods, as specified. Wet cure 7 days minimum at 50 degrees minimum temperature.
- D. Provide moisture curing by the following methods:
 - 1. Keep concrete surface continuously wet by covering with water.
 - 2. Use continuous water-fog spray.
 - 3. Cover concrete surface with specified absorptive cover, thoroughly saturate cover with water, and keep continuously wet. Place absorptive cover to provide coverage of concrete surfaces and edges, with a 4-inch lap over adjacent absorptive covers.
- E. Provide moisture-retaining cover curing as follows: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width with sides and ends lapped at least 3 inches and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
- F. Apply curing compound on exposed interior slabs and on exterior slabs, walks, and curbs as

follows:

1. Apply curing compound to concrete slabs as soon as final finishing operations are complete (within 2 hours and after surface water sheen has disappeared). Apply uniformly in continuous operation by power spray or roller according to manufacturer's directions. Re-coat areas subjected to heavy rainfall within 3 hours after initial application. Maintain continuity of coating and repair damage during curing period.
 2. Use membrane curing compounds that will not affect surfaces to be covered with finish materials applied directly to concrete.
- G. Curing Formed Surfaces: Cure formed concrete surfaces, including underside of beams, supported slabs, and other similar surfaces, by moist curing with forms in place for the full curing period or until forms are removed. If forms are removed, continue curing by methods specified above, as applicable.
- H. Curing Unformed Surfaces: Cure unformed surfaces, including slabs, floor topping, and other flat surfaces, by applying the appropriate curing method.
1. Final cure concrete surfaces to receive finish flooring with a moisture-retaining cover, unless otherwise directed.
- 3.8 CONCRETE SURFACE REPAIRS
- A. Patching Defective Areas: Repair and patch defective areas with cement mortar immediately after removing forms, when acceptable to Architect.
- B. Mix dry-pack mortar, consisting of one part portland cement to 2-1/2 parts fine aggregate passing a No. 16 mesh sieve, using only enough water as required for handling and placing.
1. Cut out honeycombs, rock pockets, voids over 1/4 inch in any dimension, and holes left by tie rods and bolts down to solid concrete but in no case to a depth less than 1 inch. Make edges of cuts perpendicular to the concrete surface. Thoroughly clean, dampen with water, and brush-coat the area to be patched with bonding agent. Place patching mortar before bonding agent has dried.
 2. For surfaces exposed to view, blend white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Provide test areas at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike-off slightly higher than surrounding surface.
- C. Repairing Formed Surfaces: Remove and replace concrete having defective surfaces if defects cannot be repaired to satisfaction of Architect. Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycomb, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning. Flush out form tie holes and fill with dry-pack mortar or precast cement cone plugs secured in place with bonding agent.
1. Repair concealed formed surfaces, where possible, containing defects that affect the concrete's durability. If defects cannot be repaired, remove and replace the concrete.
- D. Repairing Unformed Surfaces: Test unformed surfaces, such as monolithic slabs, for smoothness and verify surface tolerances specified for each surface and finish. Correct low and high areas as specified. Test unformed surfaces sloped to drain for trueness of slope and smoothness by using a template having the required slope.
1. Repair finished unformed surfaces containing defects that affect the concrete's durability.

Surface defects include crazing and cracks in excess of 0.01 inch wide or that penetrate to the reinforcement or completely through non-reinforced sections regardless of width, spalling, popouts, honeycombs, rock pockets, and other objectionable conditions.

2. Correct high areas in unformed surfaces by grinding after concrete has cured at least 14 days.
 3. Correct low areas in unformed surfaces during or immediately after completing surface finishing operations by cutting out low areas and replacing with patching mortar. Finish repaired areas to blend into adjacent concrete. Proprietary underlayment compounds may be used when acceptable to Architect.
 4. Repair defective areas, except random cracks and single holes not exceeding 1 inch in diameter, by cutting out and replacing with fresh concrete. Remove defective areas with clean, square cuts and expose reinforcing steel with at least 3/4-inch clearance all around. Dampen concrete surfaces in contact with patching concrete and apply bonding agent. Mix patching concrete of same materials to provide concrete of same type or class as original concrete. Place, compact, and finish to blend with adjacent finished concrete. Cure in same manner as adjacent concrete.
- E. Repair isolated random cracks and single holes 1 inch or less in diameter by dry-pack method. Groove top of cracks and cut out holes to sound concrete and clean of dust, dirt, and loose particles. Dampen cleaned concrete surfaces and apply bonding compound. Place dry-pack before bonding agent has dried. Compact dry-pack mixture in place and finish to match adjacent concrete. Keep patched area continuously moist for at least 72 hours.
- F. Perform structural repairs with prior approval of Architect for method and procedure, using specified epoxy adhesive and mortar.
- G. Repair methods not specified above may be used, subject to acceptance of Architect.

END OF SECTION 03 30 00

SECTION 23 05 00 - COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Mechanical equipment coordination and installation.
 - 2. Common mechanical installation requirements.
 - 3. Commissioning requirements.

1.3 GENERAL REQUIREMENTS

- A. Carefully examine General Conditions, other specification sections, and other drawings (in addition to DIVISION 23), in order to be fully acquainted with their effect on mechanical work. Additions to the contract cost will not be allowed due to failure to inspect existing conditions.
- B. Do all work in compliance with 2017 Florida Building Code, and the Codes adopted therein, 2017 Florida Fire Prevention Code.
- C. Cooperate and coordinate with all other trades. Perform work in such manner and at such times as not to delay work of other trades. Complete all work as soon as the condition of the structure and installations of equipment will permit. Patch, in a satisfactory manner and by the proper craft, any work damaged by mechanical workmen.
- D. Furnish, perform, or otherwise provide all labor (including, but not limited to, all planning, purchasing, transporting, rigging, hoisting, storing, installing, testing, chasing, channeling, cutting, trenching, excavating and backfilling), coordination, field verification, equipment installation, support, and safety, supplies, and materials necessary for the correct installation of complete and functional mechanical systems (as described or implied by these specifications and the applicable drawings).

1.4 DRAWINGS:

- A. Indicate only diagrammatically the extent, general character, and approximate location of work. Where work is indicated, but with minor details omitted, furnish and install it complete and so as to perform its intended functions.
- B. DIVISION 23 work called for under any section of the project specifications, shall be considered as included in this work unless specifically excluded by inclusion in some other branch of the work. This shall include roughing-in for connections and equipment as called for or inferred. This would include connection and ductwork required for all fans, hoods, dryers, diffusers etc as required for a functional installation, whether shown on the drawings or not. Check all drawings

and specifications for the project and shall be responsible for the installation of all DIVISION 23 work.

- C. Take finish dimensions at the job site in preference to scale dimensions. Do not scale drawings where specific details and dimensions for DIVISION 23 work are not shown on the drawings, take measurements and make layouts as required for the proper installation of the work and coordination with all drawings and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications that have not been clarified by addendum prior to bidding, it shall be assumed by the signing of the contract that the higher cost (if any difference in costs) is included in the contract price, and perform the work in accordance with the drawings or with the specifications, as determined and approved by the Architect/ Engineer, and no additional costs shall be allowed to the base contract price.
- D. Carefully check the drawings and specifications of all trades and divisions before installing any of the work. Contractor shall in all cases consider the work of all other trades, and shall coordinate his work with them so that the best arrangements of all equipment, piping, conduit, ducts, rough-in, etc., can be obtained. The avoidance of any beams, joist or bracing that is an obstruction to ductwork, shall be included in the bid. This includes the reroute of ductwork or dimension revisions required to obtain the intended function of the ductwork. Bring all obstructions to the attention of the A/E during the shop drawing preparation and prior to fabrication of any ductwork. No cost will be paid by the owner for these modifications that can be identified by reviewing all sets of drawings prior to bid.
- E. Provide appropriately rated fire dampers or fire/smoke dampers as required by code at penetrations of fire rated or smoke rated walls by all duct work including but not limited to air supply, return, exhaust and ventilation ducts. These shall be provided at no additional cost whether shown on the drawings or not.
- F. Coordinate mechanical equipment voltage requirements with electrical drawings. Notify the A/E of any discrepancies prior to bid. Make all revisions required to coordinate with no additional cost to the owner.
- G. Obtain manufacturer's data on all equipment, the dimensions of which may affect mechanical work. Use this data to coordinate proper service characteristics, entry locations, etc., and to ensure minimum clearances are maintained.

1.5 SITE VISIT/CONDITIONS

- A. Visit the site of this contract and thoroughly familiarize with all existing field conditions and the proposed work as described or implied by the contract documents. During the course of his site visit, verify every aspect of the proposed work and the existing field conditions in the areas of construction which might affect his work. No compensation or reimbursement for additional expenses incurred due to failure or neglect to make a thorough investigation of the contract documents and the existing site conditions will be permitted.
- B. Install all equipment so that all Code required and Manufacturer recommended servicing clearances are maintained. Coordinate the proper arrangement and installation of all equipment within any designated space. If it is determined that a departure from the Contract Documents is necessary, submit to the A/E, for approval, detailed drawings of the proposed changes with written reasons for the changes. No changes shall be implemented without the approval of the engineer.

- C. Submission of a proposal will be construed as evidence that such examination has been made and later claims for labor, equipment or materials required because of difficulties encountered will not be recognized.
- D. Existing conditions and utilities indicated are taken from existing construction documents, surveys, and field investigations. Unforeseen conditions probably exist and existing conditions shown on drawings may differ from the actual existing installation with the result being that new work may not be field located exactly as shown on the drawings. Field verify dimensions of all site conditions prior to bidding and include any deviations in the contract. Notify A/E if deviations are found.
- E. All existing mechanical is not shown. Become familiar with all existing conditions prior to bidding, and include in the bid the removal of all mechanical equipment, duct, controls wiring, control devices, and control conduits, etc. that is not being reused, back to it's originating point.
- F. Locate all existing utilities and protect them from damage. Pay for repair or replacement of utilities or other property damaged by operations in conjunction with the completion of this work.
- G. Work is in connection with existing buildings which must remain in operation while work is being performed. Work shall be in accord with the schedule required by the Contract. Schedule work for a minimum shut down to Owner. Notify Owner 72 hours in advance of any shut-down of existing systems. Perform work during non-operating hours unless otherwise accepted by Owner. Protect existing buildings and equipment during construction.

1.6 COMMISSIONING RESPONSIBILITIES

- A. Attend commissioning meetings scheduled by the CM.
- B. Schedule work so that required mechanical installations are completed, and system verification checks and functional performance test can be carried out on schedule.
- C. Inspect, check and confirm in writing the proper installation and performance of all mechanical services as required by the system verification and functional performance testing requirements of mechanical equipment in the commissioning specifications.
- D. Provide qualified personnel to assist and operate mechanical system during system verification checks and functional performance testing of HVAC systems as required by the commissioning specifications.
- E. Provide instruction and demonstrations for the Owner's designated operating staff in accordance with the requirements of the commissioning specifications.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR MECHANICAL INSTALLATION

- A. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- B. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- C. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both mechanical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- D. All work shall be executed in a workmanship manner and shall present a neat mechanical appearance upon completion.
- E. Care shall be exercised that all items are plumb, straight, level.
- F. Care shall be exercised so that Code clearance is allowed for all panels, controls. etc., requiring it. Do not allow other trades to infringe on this clearance.
- G. The electrical circuits, components and controls for all equipment are selected and sized based on the equipment specified. If substitutions are proposed, furnish all materials and data required to prove equivalence. No additional charges shall be allowed if additional materials, labor, connections or equipment are needed for substituted products. Any modifications to the electrical design and installation or other trades will also need to be made at no additional cost to the Owner to accommodate the proposed substitutions. Comply with division 1 "substitutions" if allowable.

END OF SECTION 23 05 00

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.3 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Comply with IEEE 841 for severe-duty motors.

2.2 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.3 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- J. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- B. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

2.5 SINGLE-PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

- C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

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SECTION 23 05 29 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal-hanger shield inserts.
 - 5. Fastener systems.
 - 6. Pipe stands.

1.3 DEFINITIONS

- A. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

1.4 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 - 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 - 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Pipe stands.
- C. Welding certificates.

1.6 QUALITY ASSURANCE

- A. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

PART 2 - PRODUCTS

2.1 METAL PIPE HANGERS AND SUPPORTS

- A. Carbon-Steel Pipe Hangers and Supports:
 - 1. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
 - 2. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
 - 3. Nonmetallic Coatings: Plastic coating, jacket, or liner.
 - 4. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
 - 5. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.

2.2 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

2.3 METAL FRAMING SYSTEMS

- A. Non-MFMA Manufacturer Metal Framing Systems:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International; a subsidiary of Mueller Water Products Inc.
 - b. Empire Industries, Inc.
 - c. ERICO International Corporation.
 - d. Haydon Corporation; H-Strut Division.
 - e. PHD Manufacturing, Inc.
 - f. PHS Industries, Inc.
 - 2. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
 - 3. Standard: Comply with MFMA-4.
 - 4. Channels: Continuous slotted steel channel with inturned lips.
 - 5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
 - 6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
 - 7. Coating: Zinc.

2.4 THERMAL-HANGER SHIELD INSERTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Carpenter & Paterson, Inc.

2. Clement Support Services.
3. ERICO International Corporation.
4. National Pipe Hanger Corporation.
5. PHS Industries, Inc.
6. Pipe Shields, Inc.; a subsidiary of Piping Technology & Products, Inc.
7. Piping Technology & Products, Inc.
8. Rilco Manufacturing Co., Inc.
9. Value Engineered Products, Inc.

- B. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
- C. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- D. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- E. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.

2.5 FASTENER SYSTEMS

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

2.6 PIPE STANDS

- A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support piping.
- B. High-Type, Single-Pipe Stand:
 1. Description: Assembly of base, vertical and horizontal members, and pipe support. Base: Stainless steel.
 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 3. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
- C. High-Type, Multiple-Pipe Stand:
 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 2. Bases: One or more; plastic.
 3. Vertical Members: Two or more protective-coated-steel channels.
 4. Horizontal Member: Protective-coated-steel channel.
 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.

2.7 MISCELLANEOUS MATERIALS

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

- B. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Nonstaining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
 - 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
 - 2. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
- D. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth surface.
- G. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.

- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
- M. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe: Not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
 - b. NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.
 - 5. Pipes NPS 8 (DN 200) and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
 - 6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

3.2 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.3 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1-1/2 inches (40 mm).

3.4 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.5 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use carbon-steel pipe hangers and supports and attachments for general service applications.
- F. Use padded hangers for piping that is subject to scratching.
- G. Use thermal-hanger shield inserts for insulated piping and tubing.
- H. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Pipe Stanchion Saddles (MSS Type 37): For support of pipes NPS 4 to NPS 36 (DN 100 to DN 900), with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
- I. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers NPS 3/4 to NPS 24 (DN 24 to DN 600).
- J. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.

2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
 3. C-Clamps (MSS Type 23): For structural shapes.
- K. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
- L. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29

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SECTION 23 05 53 - IDENTIFICATION FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Duct labels.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

- A. Plastic Labels for Equipment:
 - 1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
 - 2. Letter Color: White.
 - 3. Background Color: Black.
 - 4. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
 - 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering

for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

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

- B. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules).
- C. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.2 DUCT LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: White.
- C. Background Color: Per section 3.4.
- D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 4 by 2-4 inch.
- F. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- G. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 2. Lettering Size: At least 1-1/2 inches.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Clean equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

- C. When equipment is located above the ceiling install label on the ceiling grid T-bar below the equipment and on equipment.

3.3 DUCT LABEL INSTALLATION

- A. Install duct labels with permanent adhesive on air ducts in the following color codes:
 - 1. Blue: For cold-air supply ducts.
 - 2. Yellow: For hot-air supply ducts.
 - 3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
 - 4. ASME A13.1 Colors and Designs: For hazardous material exhaust.
- B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

END OF SECTION 23 05 53

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SECTION 23 05 93- TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes TAB to produce design objectives for the following:
 1. Air Systems: Variable-air-volume systems.
 2. Hydronic Piping Systems: Constant-flow systems.
 3. HVAC equipment quantitative-performance settings.
 4. Kitchen hood airflow balancing.
 5. Vibration measuring.
 6. Verifying that automatic control devices are functioning properly.
 7. Reporting results of activities and procedures specified in this Section.

1.3 DEFINITIONS

- A. Adjust: To regulate fluid flow rate and air patterns at the terminal equipment, such as to reduce fan speed or adjust a damper.
- B. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.
- C. Barrier or Boundary: Construction, either vertical or horizontal, such as walls, floors, and ceilings that are designed and constructed to restrict the movement of airflow, smoke, odors, and other pollutants.
- D. Draft: A current of air, when referring to localized effect caused by one or more factors of high air velocity, low ambient temperature, or direction of airflow, whereby more heat is withdrawn from a person's skin than is normally dissipated.
- E. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.
- F. Report Forms: Test data sheets for recording test data in logical order.
- G. Static Head: The pressure due to the weight of the fluid above the point of measurement. In a closed system, static head is equal on both sides of the pump.
- H. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.
- I. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
- J. System Effect Factors: Allowances used to calculate a reduction of the performance ratings of a fan when installed under conditions different from those presented when the fan was performance tested.

- K. TAB: Testing, adjusting, and balancing.
- L. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.
- M. Test: A procedure to determine quantitative performance of systems or equipment.
- N. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

1.4 SUBMITTALS

- A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit 2 copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Contract Documents Examination Report: Within 45 days from Contractor's Notice to Proceed, submit 6 copies of the Contract Documents review report as specified in Part 3.
- C. Strategies and Procedures Plan: Within 60 days from Contractor's Notice to Proceed, submit 2 copies of TAB strategies and step-by-step procedures as specified in Part 3 "Preparation" Article. Include a complete set of report forms intended for use on this Project.
- D. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.
- E. Sample Report Forms: Submit two sets of sample TAB report forms.
- F. Warranties specified in this Section.

1.5 QUALITY ASSURANCE

- A. TAB Firm Qualifications: Engage a TAB firm certified by either AABC or NEBB.
- B. Certification of TAB Reports: Certify TAB field data reports. This certification includes the following:
 - 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 - 2. Certify that TAB team complied with approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."
- D. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems."
- E. Instrumentation Calibration: Calibrate instruments at least every six months or more frequently if required by instrument manufacturer.
 - 1. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 PROJECT CONDITIONS

- A. Owner Occupancy: Owner will not occupy the building during entire TAB period. T&B reports shall be finalized and approved prior to owner occupancy.
- B. T&B firm shall be independent from the mechanical contractor.

1.7 COORDINATION

- A. Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist TAB activities.
- B. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- C. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

1.8 WARRANTY

- A. National Project Performance Guarantee: Provide a guarantee on AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that AABC will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee includes the following provisions:
 - 1. The certified TAB firm has tested and balanced systems according to the Contract Documents.
 - 2. Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
 - 1. Contract Documents are defined in the General and Supplementary Conditions of Contract.
 - 2. Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- B. Examine approved submittal data of HVAC systems and equipment.
- C. Examine Project Record Documents described in Division 1 Section "Project Record Documents."
- D. Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

- E. Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.
- F. Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.
- G. Examine system and equipment test reports.
- H. Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.
- I. Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.
- J. Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- K. Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.
- L. Examine strainers for clean screens and proper perforations.
- M. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
- N. Examine system pumps to ensure absence of entrained air in the suction piping.
- O. Examine equipment for installation and for properly operating safety interlocks and controls.
- P. Examine automatic temperature system components to verify the following:
 - 1. Dampers, valves, and other controlled devices are operated by the intended controller.
 - 2. Dampers and valves are in the position indicated by the controller.
 - 3. Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air-volume terminals.
 - 4. Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.
 - 5. Thermostats and humidistats are located to avoid adverse effects of sunlight, drafts, and cold walls.
 - 6. Sensors are located to sense only the intended conditions.
 - 7. Sequence of operation for control modes is according to the Contract Documents.
 - 8. Controller set points are set at indicated values.
 - 9. Interlocked systems are operating.
 - 10. Changeover from heating to cooling mode occurs according to indicated values.

- Q. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. Complete system readiness checks and prepare system readiness reports. Verify the following:
 1. Permanent electrical power wiring is complete.
 2. Hydronic systems are filled, clean, and free of air.
 3. Automatic temperature-control systems are operational.
 4. Equipment and duct access doors are securely closed.
 5. Balance, smoke, and fire dampers are open.
 6. Isolating and balancing valves are open and control valves are operational.
 7. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
 8. Windows and doors can be closed so indicated conditions for system operations can be met.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" and this Section.
- B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.
- C. Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, to show final settings.
- D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

- A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
- B. Prepare schematic diagrams of systems' "as-built" duct layouts.
- C. For variable-air-volume systems, develop a plan to simulate diversity.
- D. Determine the best locations in main and branch ducts for accurate duct airflow measurements.
- E. Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.
- F. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

- G. Verify that motor starters are equipped with properly sized thermal protection.
- H. Check dampers for proper position to achieve desired airflow path.
- I. Check for airflow blockages.
- J. Check condensate drains for proper connections and functioning.
- K. Check for proper sealing of air-handling unit components.
- L. Check for proper sealing of air duct system.

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set-point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.
 - 2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
 - 3. Measure total system airflow. Adjust to within indicated airflow.
 - 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 - 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 - 6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
 - 7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 - 8. Record the final fan performance data.
- C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
 - 1. Balance systems similar to constant-volume air systems.
 - 2. Set terminal units and supply fan at full-airflow condition.
 - 3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 - 4. Readjust fan airflow for final maximum readings.

5. Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.
 6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
 7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
 8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.
- D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
 2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
 3. Set terminal units at full-airflow condition.
 4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.
 5. Adjust terminal units for minimum airflow.
 6. Measure static pressure at the sensor.
 7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

- A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
- B. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:
 1. Open all manual valves for maximum flow.
 2. Check expansion tank liquid level.
 3. Check makeup-water-station pressure gage for adequate pressure for highest vent.
 4. Check flow-control valves for specified sequence of operation and set at indicated flow.
 5. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
 6. Set system controls so automatic valves are wide open to heat exchangers.
 7. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
 8. Check air vents for a forceful liquid flow exiting from vents when manually operated.

3.7 PROCEDURES FOR HYDRONIC SYSTEMS

- A. Measure water flow at pumps. Use the following procedures, except for positive-displacement pumps:
 - 1. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
 - 2. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
 - 3. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
 - 4. Report flow rates that are not within plus or minus 5 percent of design.
- B. Set calibrated balancing valves, if installed, at calculated presettings.
- C. Measure flow at all stations and adjust, where necessary, to obtain first balance.
 - 1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
- D. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
- E. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
 - 1. Determine the balancing station with the highest percentage over indicated flow.
 - 2. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
 - 3. Record settings and mark balancing devices.
- F. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
- G. Measure the differential-pressure control valve settings existing at the conclusions of balancing.

3.8 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 - 1. Manufacturer, model, and serial numbers.
 - 2. Motor horsepower rating.
 - 3. Motor rpm.
 - 4. Efficiency rating.
 - 5. Nameplate and measured voltage, each phase.
 - 6. Nameplate and measured amperage, each phase.
 - 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.9 PROCEDURES FOR CHILLERS

- A. Balance water flow through each evaporator to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
 - 1. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
 - 2. .
 - 3. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
 - 4. Power factor if factory-installed instrumentation is furnished for measuring kilowatt.
 - 5. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatt.
 - 6. Capacity: Calculate in tons of cooling.
 - 7. If air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.10 PROCEDURES FOR TEMPERATURE MEASUREMENTS

- A. During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.
- B. Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.
- C. Measure outside-air, wet- and dry-bulb temperatures.
- D. Measure air-coil inlet and outlet water and air temperatures and flow rates.

3.11 PROCEDURES FOR COMMERCIAL KITCHEN HOODS

- A. Measure, adjust, and record the airflow of kitchen hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
 - 1. Install welded test ports in the sides of the exhaust duct for the duct Pitot-tube traverse. Install each test port with a threaded cap that is liquid tight.
- B. After balancing is complete, do the following:
 - 1. Measure and record the static pressure at the hood exhaust-duct connection.
 - 2. Report deficiencies.

3.12 TEMPERATURE-CONTROL VERIFICATION

- A. Verify that controllers are calibrated and commissioned.
- B. Check transmitter and controller locations and note conditions that would adversely affect control functions.
- C. Record controller settings and note variances between set points and actual measurements.
- D. Check the operation of limiting controllers (i.e., high- and low-temperature controllers).
- E. Check free travel and proper operation of control devices such as damper and valve operators.

- F. Check the sequence of operation of control devices. Note air pressures and device positions and correlate with airflow and water flow measurements. Note the speed of response to input changes.
- G. Check the interaction of electrically operated switch transducers.
- H. Check the interaction of interlock and lockout systems.
- I. Check main control supply-air pressure and observe compressor and dryer operations.
- J. Record voltages of power supply and controller output. Determine whether the system operates on a grounded or non-grounded power supply.
- K. Note operation of electric actuators using spring return for proper fail-safe operations.

3.13 TOLERANCES

- A. Set HVAC system airflow and water flow rates within the following tolerances:
 - 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 - 2. Air Outlets and Inlets: Plus or minus 10 percent.
 - 3. Cooling-Water Flow Rate: Plus or minus 10 percent.

3.14 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: As Work progresses, prepare reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.15 FINAL REPORT

- A. General: Typewritten, or computer printout in letter-quality font, on standard bond paper, in three-ring binder, tabulated and divided into sections by tested and balanced systems.
- B. Include a certification sheet in front of binder signed and sealed by the certified testing and balancing engineer.
 - 1. Include a list of instruments used for procedures, along with proof of calibration.
- C. Final Report Contents: In addition to certified field report data, include the following:
 - 1. Pump curves.
 - 2. Fan curves.
 - 3. Manufacturers' test data.
 - 4. Field test reports prepared by system and equipment installers.
 - 5. Other information relative to equipment performance, but do not include Shop Drawings and Product Data.

- D. General Report Data: In addition to form titles and entries, include the following data in the final report, as applicable:
1. Title page.
 2. Name and address of TAB firm.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB firm who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer, type size, and fittings.
 14. Notes to explain why certain final data in the body of reports varies from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outside-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- E. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
1. Quantities of outside, supply, return, and exhaust airflows.
 2. Water flow rates.
 3. Duct, outlet, and inlet sizes.
 4. Pipe and valve sizes and locations.
 5. Terminal units.
 6. Balancing stations.
 7. Position of balancing devices.
- F. Air-Handling Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data: Include the following:
 - a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches (mm), and bore.
 - i. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 - j. Number of belts, make, and size.

- k. Number of filters, type, and size.
 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Filter static-pressure differential in inches wg (Pa).
 - f. Preheat coil static-pressure differential in inches wg (Pa).
 - g. Cooling coil static-pressure differential in inches wg (Pa).
 - h. Heating coil static-pressure differential in inches wg (Pa).
 - i. Outside airflow in cfm (L/s).
 - j. Return airflow in cfm (L/s).
 - k. Outside-air damper position.
 - l. Return-air damper position.
 - m. Vortex damper position.
- G. Apparatus-Coil Test Reports:
 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Fin spacing in fins per inch (mm) o.c.
 - f. Make and model number.
 - g. Face area in sq. ft. (sq. m).
 - h. Tube size in NPS (DN).
 - i. Tube and fin materials.
 - j. Circuiting arrangement.
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Average face velocity in fpm (m/s).
 - c. Air pressure drop in inches wg (Pa).
 - d. Outside-air, wet- and dry-bulb temperatures in deg F (deg C).
 - e. Return-air, wet- and dry-bulb temperatures in deg F (deg C).
 - f. Entering-air, wet- and dry-bulb temperatures in deg F (deg C).
 - g. Leaving-air, wet- and dry-bulb temperatures in deg F (deg C).
 - h. Water flow rate in gpm (L/s).
 - i. Water pressure differential in feet of head or psig (kPa).
 - j. Entering-water temperature in deg F (deg C).
 - k. Leaving-water temperature in deg F (deg C).
 - l. Refrigerant expansion valve and refrigerant types.
 - m. Refrigerant suction pressure in psig (kPa).
 - n. Refrigerant suction temperature in deg F (deg C).
 - o. Inlet steam pressure in psig (kPa).

- H. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
1. Unit Data:
 - a. System identification.
 - b. Location.
 - c. Coil identification.
 - d. Capacity in Btuh (kW).
 - e. Number of stages.
 - f. Connected volts, phase, and hertz.
 - g. Rated amperage.
 - h. Airflow rate in cfm (L/s).
 - i. Face area in sq. ft. (sq. m).
 - j. Minimum face velocity in fpm (m/s).
 2. Test Data (Indicated and Actual Values):
 - a. Heat output in Btuh (kW).
 - b. Airflow rate in cfm (L/s).
 - c. Air velocity in fpm (m/s).
 - d. Entering-air temperature in deg F (deg C).
 - e. Leaving-air temperature in deg F (deg C).
 - f. Voltage at each connection.
 - g. Amperage for each phase.
- I. Fan Test Reports: For supply, return, and exhaust fans, include the following:
1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches (mm), and bore.
 - h. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 2. Motor Data:
 - a. Make and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).
 - g. Number of belts, make, and size.
 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg (Pa).
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg (Pa).
 - e. Suction static pressure in inches wg (Pa).
- J. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
1. Report Data:

- a. System and air-handling unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F (deg C).
 - d. Duct static pressure in inches wg (Pa).
 - e. Duct size in inches (mm).
 - f. Duct area in sq. ft. (sq. m).
 - g. Indicated airflow rate in cfm (L/s).
 - h. Indicated velocity in fpm (m/s).
 - i. Actual airflow rate in cfm (L/s).
 - j. Actual average velocity in fpm (m/s).
 - k. Barometric pressure in psig (Pa).
- K. Air-Terminal-Device Reports:
1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.
 - c. Test apparatus used.
 - d. Area served.
 - e. Air-terminal-device make.
 - f. Air-terminal-device number from system diagram.
 - g. Air-terminal-device type and model number.
 - h. Air-terminal-device size.
 - i. Air-terminal-device effective area in sq. ft. (sq. m).
 2. Test Data (Indicated and Actual Values):
 - a. Airflow rate in cfm (L/s).
 - b. Air velocity in fpm (m/s).
 - c. Preliminary airflow rate as needed in cfm (L/s).
 - d. Preliminary velocity as needed in fpm (m/s).
 - e. Final airflow rate in cfm (L/s).
 - f. Final velocity in fpm (m/s).
 - g. Space temperature in deg F (deg C).
- L. Packaged Chiller Reports:
1. Unit Data:
 - a. Unit identification.
 - b. Make and model number.
 - c. Manufacturer's serial number.
 - d. Refrigerant type and capacity in gal. (L).
 - e. Starter type and size.
 - f. Starter thermal protection size.
 - g. Compressor make and model number.
 - h. Compressor manufacturer's serial number.
 2. Air-Cooled Condenser Test Data (Indicated and Actual Values):
 - a. Refrigerant pressure in psig (kPa).
 - b. Refrigerant temperature in deg F (deg C).
 - c. Entering- and leaving-air temperature in deg F (deg C).
 3. Evaporator Test Reports (Indicated and Actual Values):
 - a. Refrigerant pressure in psig (kPa).
 - b. Refrigerant temperature in deg F (deg C).
 - c. Entering-water temperature in deg F (deg C).
 - d. Leaving-water temperature in deg F (deg C).

- e. Entering-water pressure in feet of head or psig (kPa).
- f. Water pressure differential in feet of head or psig (kPa).
- 4. Compressor Test Data (Indicated and Actual Values):
 - a. Suction pressure in psig (kPa).
 - b. Suction temperature in deg F (deg C).
 - c. Discharge pressure in psig (kPa).
 - d. Discharge temperature in deg F (deg C).
 - e. Oil pressure in psig (kPa).
 - f. Oil temperature in deg F (deg C).
 - g. Voltage at each connection.
 - h. Amperage for each phase.
 - i. Kilowatt input.
 - j. Crankcase heater kilowatt.
 - k. Chilled-water control set point in deg F (deg C).
 - l. Condenser-water control set point in deg F (deg C).
 - m. Refrigerant low-pressure-cutoff set point in psig (kPa).
 - n. Refrigerant high-pressure-cutoff set point in psig (kPa).
- 5. Refrigerant Test Data (Indicated and Actual Values):
 - a. Oil level.
 - b. Refrigerant level.
 - c. Relief valve setting in psig (kPa).
 - d. Unloader set points in psig (kPa).
 - e. Percentage of cylinders unloaded.
 - f. Bearing temperatures in deg F (deg C).
 - g. Vane position.
 - h. Low-temperature-cutoff set point in deg F (deg C).
- M. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
 - 1. Unit Data:
 - a. Unit identification.
 - b. Location.
 - c. Service.
 - d. Make and size.
 - e. Model and serial numbers.
 - f. Water flow rate in gpm (L/s).
 - g. Water pressure differential in feet of head or psig (kPa).
 - h. Required net positive suction head in feet of head or psig (kPa).
 - i. Pump rpm.
 - j. Impeller diameter in inches (mm).
 - k. Motor make and frame size.
 - l. Motor horsepower and rpm.
 - m. Voltage at each connection.
 - n. Amperage for each phase.
 - o. Full-load amperage and service factor.
 - p. Seal type.
 - 2. Test Data (Indicated and Actual Values):
 - a. Static head in feet of head or psig (kPa).
 - b. Pump shutoff pressure in feet of head or psig (kPa).
 - c. Actual impeller size in inches (mm).
 - d. Full-open flow rate in gpm (L/s).
 - e. Full-open pressure in feet of head or psig (kPa).

- f. Final discharge pressure in feet of head or psig (kPa).
- g. Final suction pressure in feet of head or psig (kPa).
- h. Final total pressure in feet of head or psig (kPa).
- i. Final water flow rate in gpm (L/s).
- j. Voltage at each connection.
- k. Amperage for each phase.

3.16 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the Final Report.
- 2. Randomly check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Measure sound levels at two locations.
 - e. Measure space pressure of at least 10 percent of locations.
 - f. Verify that balancing devices are marked with final balance position.
 - g. Note deviations to the Contract Documents in the Final Report.

B. Final Inspection:

- 1. After initial inspection is complete and evidence by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
- 2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.
- 3. Architect shall randomly select measurements documented in the final report to be rechecked. The rechecking shall be limited to either 10 percent of the total measurements recorded, or the extent of measurements that can be accomplished in a normal 8-hour business day.
- 4. If the rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- 5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- 6. TAB firm shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes and resubmit the final report.
- 7. Request a second final inspection. If the second final inspection also fails, Owner shall contract the services of another TAB firm to complete the testing and balancing in accordance with the Contract Documents and deduct the cost of the services from the final payment.

3.17 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional testing and balancing to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Provide a minimum of 1 man-day of time for Cx verification of readings indicated in the final report.

SECTION 23 07 13 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed supply and outdoor air.
 - 2. Indoor, exposed supply and outdoor air.
 - 3. Indoor, concealed return located in unconditioned space.
 - 4. Indoor, exposed return located in unconditioned space.
 - 5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
 - 6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Qualification Data: For qualified Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; SoftTouch Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Friendly Feel Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; SOFTR All-Service Duct Wrap.

- G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory-applied FSK jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; Commercial Board.
 - b. Fibrex Insulations Inc.; FBX.
 - c. Johns Manville; 800 Series Spin-Glas.
 - d. Knauf Insulation; Insulation Board.
 - e. Manson Insulation Inc.; AK Board.
 - f. Owens Corning; Fiberglas 700 Series.

2.2 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 2-hour fire rating by an NRTL acceptable to authorities having jurisdiction.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.
 - c. Nelson Fire Stop Products; Nelson FSB Flameshield Blanket.
 - d. Thermal Ceramics; FireMaster Duct Wrap.
 - e. 3M; Fire Barrier Wrap Products.
 - f. Unifrax Corporation; FyreWrap.

2.3 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
 - b. Eagle Bridges - Marathon Industries; 225.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
 - d. Mon-Eco Industries, Inc.; 22-25.
- C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
- b. Eagle Bridges - Marathon Industries; 225.
- c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.
- d. Mon-Eco Industries, Inc.; 22-25.

2.4 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below ambient services.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 5. Color: White.

2.5 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 3. Fire- and water-resistant, flexible, elastomeric sealant.
 4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
 5. Color: Aluminum.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.7 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 491 AWF FSK.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - c. Compac Corporation; 110 and 111.
 - d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.
 - 2. Width: 3 inches (75 mm).
 - 3. Thickness: 6.5 mils (0.16 mm).
 - 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 - 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

2.8 SECUREMENTS

- A. Insulation Pins and Hangers:
 - 1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.
 - 4) Nelson Stud Welding; TPA, TPC, and TPS.
 - 2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch (38-mm) galvanized carbon-steel washer.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; CHP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.

- 4) Nelson Stud Welding; CHP.
 3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
 4. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches (38 mm) in diameter.
 - a. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) GEMCO.
 - 2) Midwest Fasteners, Inc.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch- (19-mm-) wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
 1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and around anchor attachments.
 - 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 - 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 INSTALLATION OF MINERAL-FIBER INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
 - 1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 - 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 - 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), place pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of vapor-barrier mastic at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
 - 5. Overlap unfaced blankets a minimum of 2 inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches (450 mm) o.c.
 - 6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 - 7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On duct sides with dimensions 18 inches (450 mm) and smaller, place pins along longitudinal centerline of duct. Space 3 inches (75 mm) maximum from insulation end joints, and 16 inches (400 mm) o.c.
 - b. On duct sides with dimensions larger than 18 inches (450 mm), space pins 16 inches (400 mm) o.c. each way, and 3 inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not overcompress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches (50 mm) from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch (13-mm) outward-clinching staples, 1 inch (25 mm) o.c. Install vapor barrier consisting of vapor-barrier mastic at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F (10 deg C) at 18-foot (5.5-m) intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches (75 mm).
 5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- (150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches (150 mm) o.c.

3.5 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.

- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping."

3.6 DUCT INSULATION SCHEDULE, GENERAL

A. Plenums and Ducts Requiring Insulation:

1. Indoor, concealed supply and outdoor air.
2. Indoor, exposed supply and outdoor air.
3. Indoor, concealed return located in unconditioned space.
4. Indoor, exposed return located in unconditioned space.
5. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust between isolation damper and penetration of building exterior.

B. Items Not Insulated:

1. Fibrous-glass ducts.
2. Metal ducts with duct liner of sufficient thickness to comply with Florida Energy Conservation Code.
3. Factory-insulated flexible ducts.
4. Factory-insulated plenums and casings.
5. Factory-insulated access panels and doors.

3.7 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, round and flat-oval, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

B. Concealed, round and flat-oval, return-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

C. Concealed, round and flat-oval, outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

D. Concealed, rectangular, supply-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

E. Concealed, rectangular, return-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

F. Concealed, rectangular, outdoor-air duct insulation shall be the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- G. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- H. Concealed, return-air plenum insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- I. Concealed, outdoor-air plenum insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- J. Exposed, round and flat-oval, supply-air duct insulation shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- K. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- L. Exposed, round, flat-oval and rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- M. Exposed, rectangular, supply-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- N. Exposed, rectangular, return-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- O. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.
- P. Exposed, return-air plenum insulation shall be one of the following:
1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

Q. Exposed, outdoor-air plenum insulation shall be one of the following:

1. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) thick and 0.75-lb/cu. ft. (12-kg/cu. m) nominal density.

END OF SECTION 23 07 13

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping, indoors.
 - 2. Chilled-water and brine piping, indoors and outdoors.
 - 3. Refrigerant piping, indoors and outdoors.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Qualification Data: For qualified Installer.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

1.6 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Pittsburgh Corning Corporation; Foamglas.
 - 2. Block Insulation: ASTM C 552, Type I.
 - 3. Special-Shaped Insulation: ASTM C 552, Type III.
 - 4. Board Insulation: ASTM C 552, Type IV.
 - 5. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
 - 6. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

- G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F (minus 73 to plus 93 deg C).
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.
- C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
 - d. K-Flex USA; R-373 Contact Adhesive.
- D. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Dow Corning Corporation; 739, Dow Silicone.
 - b. Johns Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Polyco VP Adhesive.

2.3 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.
 - 1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

- B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
 - b. Vimasco Corporation; 749.
 - 2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm (0.009 metric perm) at 43-mil (1.09-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).
 - 4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
 - 5. Color: White.

- C. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.
 - 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
 - b. Eagle Bridges - Marathon Industries; 570.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.
 - 2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm (0.033 metric perm) at 30-mil (0.8-mm) dry film thickness.
 - 3. Service Temperature Range: Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).
 - 4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
 - 5. Color: White.

2.4 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
 - b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.

- c. Vimasco Corporation; 713 and 714.
3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F (Minus 18 to plus 82 deg C).
5. Color: White.

2.5 SEALANTS

A. Joint Sealants:

1. Joint Sealants for Cellular-Glass Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Pittsburgh Corning Corporation; Pittseal 444.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Permanently flexible, elastomeric sealant.
4. Service Temperature Range: Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).
5. Color: White or gray.

B. FSK and Metal Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
 - b. Eagle Bridges - Marathon Industries; 405.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
 - d. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: Aluminum.

C. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).
5. Color: White.

2.6 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

2.7 FIELD-APPLIED FABRIC-REINFORCING MESH

- A. Woven Glass-Fiber Fabric: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. in. (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Chil-Glas Number 10.

2.8 FIELD-APPLIED CLOTHS

- A. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

2.9 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

- a. Johns Manville; Zeston.
 - b. P.I.C. Plastics, Inc.; FG Series.
 - c. Proto Corporation; LoSmoke.
 - d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
 3. Color: White.
 4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
- C. Metal Jacket:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Metal Jacketing Systems.
 - b. ITW Insulation Systems; Aluminum and Stainless Steel Jacketing.
 - c. RPR Products, Inc.; Insul-Mate.
 2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005, Temper H-14.
 - a. Sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field-applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
 - d. Factory-Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.

- c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
2. Width: 3 inches (75 mm).
 3. Thickness: 11.5 mils (0.29 mm).
 4. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ABI, Ideal Tape Division; 370 White PVC tape.
 - b. Compac Corporation; 130.
 - c. Venture Tape; 1506 CW NS.
 2. Width: 2 inches (50 mm).
 3. Thickness: 6 mils (0.15 mm).
 4. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

2.11 SECUREMENTS

- A. Bands:
1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. ITW Insulation Systems; Gerrard Strapping and Seals.
 - b. RPR Products, Inc.; Insul-Mate Strapping, Seals, and Springs.
 2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) wide with wing seal or closed seal.
 3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.
1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.

3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A.
- B. Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, for outdoor pipe apply a corrosion coating to insulated surfaces as follows:
 1. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F (0 and 149 deg C) with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install all chilled water piping insulation prior to chiller start-up to avoid bare-pipe sweating into partially installed insulation.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) o.c.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- Q. For above-ambient services, do not install insulation to the following:
1. Vibration-control devices.
 2. Testing agency labels and stamps.
 3. Nameplates and data plates.
 4. Manholes.
 5. Handholes.
 6. Cleanouts.

3.4 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.

4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.
1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
- F. Insulation Installation at Floor Penetrations:
1. Pipe: Install insulation continuously through floor penetrations.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets,

- valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches (50 mm) over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

- A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient services, secure laps with outward-clinched staples at 6 inches (150 mm) o.c.
4. For insulation with factory-applied jackets on below-ambient services, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch (25 mm), and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of cellular-glass insulation to valve body.
2. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

B. Insulation Installation on Pipe Flanges:

1. Install pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install mitered sections of pipe insulation.

2. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

D. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed valve covers manufactured of same material as pipe insulation when available.
2. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
3. Install insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

3.8 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.
 1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- B. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches (300 mm) o.c. and at end joints.

3.9 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended UV protective coating for exterior installation.
- B. Do not field paint aluminum or stainless-steel jackets.

3.10 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 1. Drainage piping located in crawl spaces.
 2. Underground piping.
 3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Condensate and Equipment Drain Water below 60 Deg F (16 Deg C):

1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 3/4 inch (19 mm) thick.
 - B. Chilled Water and Brine, above 40 Deg F (5 Deg C):
 1. NPS 12 (DN 300) and Smaller: Insulation shall be the following:
 - a. Cellular Glass: 1-1/2 inches (38 mm) thick.
 - C. Refrigerant Suction and Hot-Gas Piping:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - D. Refrigerant Suction and Hot-Gas Flexible Tubing:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1 inch (25 mm) thick.
 - E. Refrigerant Liquid Lines below 60 Deg F
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 1/2 inch thick
- 3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE
- A. Chilled Water and Brine:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Cellular Glass: 3 inches (75 mm) thick.
 - B. Refrigerant Suction and Hot-Gas Piping:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 2 inches (50 mm) thick.
 - C. Refrigerant Suction and Hot-Gas Flexible Tubing:
 1. All Pipe Sizes: Insulation shall be the following:
 - a. Flexible Elastomeric: 2 inches (50 mm) thick.
- 3.13 INDOOR, FIELD-APPLIED JACKET SCHEDULE
- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed:
 - 1. PVC: 20 mils (0.5 mm) thick.

3.14 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Piping, Concealed:
 - 1. None.
- D. Piping, Exposed:
 - 1. Aluminum, Corrugated with Z-Shaped Locking Seam: 0.020 inch (0.51 mm) thick.

END OF SECTION 23 07 19

SECTION 23 08 00 – COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Base Bid:

1. Mechanical Contractor to provide: Commissioning process support for implementing building systems commissioning for Ventilating, Air Conditioning and related systems, assemblies and equipment.
2. Controls Contractor to provide: Commissioning process support for implementing building systems commissioning for Heating, Ventilating, Air Conditioning and Refrigeration control systems, assemblies and equipment.

1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Work / Sections:
1. Section 01 91 13 - "General Commissioning Requirements" for general commissioning process requirements.
- C. ASHRAE Standard 90.1-2016 and ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.

1.3 DESCRIPTION

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for CxA's role.
- B. Refer to Section 01 33 00 "Submittals" for specific requirements.
- C. In addition, provide the following:
1. Certificates of readiness
 2. Certificates of completion of installation, pre-start, and start-up activities.
 3. Test reports

D. Control Drawings Submittal

1. The control drawings shall have a key to all abbreviations.
2. The control drawings shall contain graphic schematic depictions of the systems and each component.
3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Provide a full points list with at least the following included for each point:
 - a. Controlled system
 - b. Point abbreviation
 - c. Point description
 - d. Display unit
 - e. Control point or set point (Yes / No)
 - f. Monitoring point (Yes / No)
 - g. Intermediate point (Yes / No)
 - h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

2. PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the heating, ventilating and controls contractors shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system specified, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, 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 as needed. Proprietary test equipment (and software) shall become the property of the Using Agency upon completion of the commissioning process.

- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Using Agency.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

3. EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare construction Verification Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Heating, Ventilating, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the heating, ventilating, controls and TAB contractors are as follows (all references apply to commissioned equipment only):
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase controls coordination meetings.
- D. Attend testing, adjusting, and balancing review and coordination meetings.
- E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- F. Provide information requested by the CxA for final commissioning documentation.
- G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- H. Prepare preliminary schedule for mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing,

flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

- I. Update schedule as required throughout the construction period.
- J. During the startup and initial checkout process, execute the related portions of the Component Verification Checklists for all commissioned equipment.
- K. Assist the CxA in all verification and functional performance tests.
- L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- N. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- O. Participate in, and schedule vendors and contractors to participate in the training sessions.
- P. Provide written notification to the GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 1. Primary HVAC&R equipment including chillers, pumps, piping and all other equipment under their control.
- Q. The equipment supplier shall document the performance of his equipment.
- R. Test, Adjust and Balance Contractor
 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
 2. Submit the site specific testing and balancing plan to the CxA and A/E for review and acceptance.
 3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
 4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the GC.
 5. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
- S. Provide training of the Using Agency's operating staff using expert qualified personnel, as specified.
- T. Equipment Suppliers
 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Using Agency, to keep warranties in force.
 2. Assist in equipment testing per agreements with contractors.
 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

- U. Refer to Section 01 91 13 "General Commissioning Requirements" for additional contractor responsibilities.

3.3 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for Design Professional's Responsibilities.

3.4 CxA'S RESPONSIBILITIES

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for CxA's Responsibilities.

3.5 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.6 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA, along with the Heating and Ventilating Contractors, Testing and Balancing Subcontractor, and the Controls Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and provide a deficiency report. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual technical sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 23 09 23 "Instrument and Control for HVAC". Assist the CxA with preparation of testing plans.

- C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in piping specifications. Mechanical Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
 - 1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 - 2. Description of equipment for flushing operations.
 - 3. Minimum flushing water velocity.
 - 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
 - D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
 - E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of hydronic distribution systems and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
 - F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
 - 1. Building Automation System
 - 2. Chilled Water System
 - 3. Pumps
 - 4. Testing, Adjusting and Balancing
 - 5. Variable Frequency Drives (VFD)
- 3.9 DEFICIENCIES / NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.
- 3.10 APPROVAL
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for approval procedures.
- 3.11 DEFERRED TESTING
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to deferred testing.

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SECTION 23 08 00 – COMMISSIONING OF HVAC SYSTEMS

PART 1 - GENERAL

1.1 WORK INCLUDES

A. Base Bid:

1. Mechanical Contractor to provide: Commissioning process support for implementing building systems commissioning for Ventilating, Air Conditioning and related systems, assemblies and equipment.
2. Controls Contractor to provide: Commissioning process support for implementing building systems commissioning for Heating, Ventilating, Air Conditioning and Refrigeration control systems, assemblies and equipment.

1.2 SUMMARY

- A. This section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Work / Sections:
1. Section 01 91 13 - "General Commissioning Requirements" for general commissioning process requirements.
- C. ASHRAE Standard 90.1-2016 and ASHRAE Standard 202-2013 Commissioning Process for Buildings and Systems.

1.3 DESCRIPTION

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for the description of commissioning.

1.4 DEFINITIONS

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for definitions.

1.5 SUBMITTALS

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for CxA's role.
- B. Refer to Section 01 33 00 "Submittals" for specific requirements.
- C. In addition, provide the following:
1. Certificates of readiness
 2. Certificates of completion of installation, pre-start, and start-up activities.
 3. Test reports

D. Control Drawings Submittal

1. The control drawings shall have a key to all abbreviations.
2. The control drawings shall contain graphic schematic depictions of the systems and each component.
3. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
4. Provide a full points list with at least the following included for each point:
 - a. Controlled system
 - b. Point abbreviation
 - c. Point description
 - d. Display unit
 - e. Control point or set point (Yes / No)
 - f. Monitoring point (Yes / No)
 - g. Intermediate point (Yes / No)
 - h. Calculated point (Yes / No)

1.6 QUALITY ASSURANCE

- A. Test Equipment Calibration Requirements: Contractors will comply with test manufacturer's calibration procedures and intervals. Recalibrate test instruments immediately after instruments have been repaired resulting from being dropped or damaged. Affix calibration tags to test instruments. Furnish calibration records to CxA upon request.

1.7 COORDINATION

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to coordination during the commissioning process.

2. PRODUCTS

2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup, initial checkout and functional performance testing shall be provided by the Contractor for the equipment being tested. For example, the heating, ventilating and controls contractors shall ultimately be responsible for all standard testing equipment for the HVAC&R system and controls system specified, except for equipment specific to and used by TAB in their commissioning responsibilities. A sufficient quantity of two-way radios shall be provided by each subcontractor.
- B. Special equipment, tools and instruments (specific to a piece of equipment and only available from vendor) required for testing shall be included in the base bid price and left on site, except for stand-alone data logging equipment that may be used by the CxA.
- C. Proprietary test equipment and software required by any equipment manufacturer for programming and/or start-up, 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 as needed. Proprietary test equipment (and software) shall become the property of the Using Agency upon completion of the commissioning process.

- D. Data logging equipment and software required to test equipment will be provided by the CxA, but shall not become the property of the Using Agency.
- E. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.

3. EXECUTION

3.1 GENERAL DOCUMENTATION REQUIREMENTS

- A. With assistance from the installing contractors, the CxA will prepare construction Verification Checklists for all commissioned components, equipment, and systems
- B. Red-lined Drawings:
 - 1. The contractor will verify all equipment, systems, instrumentation, wiring and components are shown correctly on red-lined drawings.
 - 2. Preliminary red-lined drawings must be made available to the Commissioning Team for use prior to the start of Functional Performance Testing.
 - 3. Changes, as a result of Functional Testing, must be incorporated into the final as-built drawings, which will be created from the red-lined drawings.
 - 4. The contracted party, as defined in the Contract Documents will create the as-built drawings.

3.2 CONTRACTOR'S RESPONSIBILITIES

- A. Heating, Ventilating, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the heating, ventilating, controls and TAB contractors are as follows (all references apply to commissioned equipment only):
- B. Perform commissioning tests at the direction of the CxA.
- C. Attend construction phase controls coordination meetings.
- D. Attend testing, adjusting, and balancing review and coordination meetings.
- E. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
- F. Provide information requested by the CxA for final commissioning documentation.
- G. Include requirements for submittal data, operation and maintenance data, and training in each purchase order or sub-contract written.
- H. Prepare preliminary schedule for mechanical system orientations and inspections, operation and maintenance manual submissions, training sessions, pipe and duct system testing,

flushing and cleaning, equipment start-up, testing and balancing and task completion for owner. Distribute preliminary schedule to commissioning team members.

- I. Update schedule as required throughout the construction period.
- J. During the startup and initial checkout process, execute the related portions of the Component Verification Checklists for all commissioned equipment.
- K. Assist the CxA in all verification and functional performance tests.
- L. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.
- M. Coordinate with the CxA to provide (48) hour advance notice so that the witnessing of equipment and system start-up and testing can begin.
- N. Notify the CxA a minimum of (2) weeks in advance of the time for start of the testing and balancing work. Attend the initial testing and balancing meeting for review of the official testing and balancing procedures.
- O. Participate in, and schedule vendors and contractors to participate in the training sessions.
- P. Provide written notification to the GC and CxA Authority that the following work has been completed in accordance with the contract documents, and that the equipment, systems, and sub-system are operating as required.
 - 1. Primary HVAC&R equipment including chillers, pumps, piping and all other equipment under their control.
- Q. The equipment supplier shall document the performance of his equipment.
- R. Test, Adjust and Balance Contractor
 - 1. Attend initial commissioning coordination meeting scheduled by the Commissioning Authority.
 - 2. Submit the site specific testing and balancing plan to the CxA and A/E for review and acceptance.
 - 3. Attend the testing and balancing review meeting scheduled by the CxA. Be prepared to discuss the procedures that shall be followed in testing, adjusting, and balancing the HVAC&R system.
 - 4. At the completion of the testing and balancing work, and the submittal of the final testing and balancing report, notify the HVAC&R contractor and the GC.
 - 5. Participate in verification of the testing and balancing report, which will consist of repeating measurements contained in the testing and balancing reports. Assist in diagnostic purposes when directed.
- S. Provide training of the Using Agency's operating staff using expert qualified personnel, as specified.
- T. Equipment Suppliers
 - 1. Provide all requested submittal data, including detailed start-up procedures and specific responsibilities of the Using Agency, to keep warranties in force.
 - 2. Assist in equipment testing per agreements with contractors.
 - 3. Provide information requested by CxA regarding equipment sequence of operation and testing procedures.

- U. Refer to Section 01 91 13 "General Commissioning Requirements" for additional contractor responsibilities.

3.3 DESIGN PROFESSIONAL'S RESPONSIBILITIES

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for Design Professional's Responsibilities.

3.4 CxA'S RESPONSIBILITIES

- A. Refer to Section 01 91 13 "General Commissioning Requirements" for CxA's Responsibilities.

3.5 TESTING PREPARATION

- A. Certify in writing to the CxA that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
- B. Certify in writing to the CxA that HVAC&R instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.
- C. Certify in writing that testing, adjusting, and balancing procedures have been completed and that testing, adjusting, and balancing reports have been submitted, discrepancies corrected, and corrective work approved.
- D. Place systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- E. Inspect and verify the position of each device and interlock identified on checklists.
- F. Check safety cutouts, alarms, and interlocks with smoke control and life-safety systems during each mode of operation.
- G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.6 TESTING, ADJUSTING AND BALANCING VERIFICATION

- A. Prior to performance of Testing, Adjusting and Balancing work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
- B. Notify the CxA at least ten (10) days in advance of testing and balancing Work, and provide access for the CxA to witness testing and balancing Work.
- C. Provide technicians, instrumentation, and tools to verify testing and balancing of HVAC&R systems at the direction of the CxA.
 - 1. The CxA will notify testing and balancing subcontractor ten (10) days in advance of the date of field verification. Notice will not include data points to be verified.
 - 2. The testing and balancing subcontractor shall use the same instruments (by model and serial number) that were used when original data were collected.

3. Failure of an item includes, other than sound, a deviation of more than 10 percent. Failure of more than 10 percent of selected items shall result in rejection of final testing, adjusting, and balancing report. For sound pressure readings, a deviation of 3 dB shall result in rejection of final testing. Variations in background noise must be considered.
4. Remedy the deficiency and notify the CxA so verification of failed portions can be performed.

3.7 GENERAL TESTING REQUIREMENTS

- A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.
- B. Scope of HVAC&R testing shall include entire HVAC&R installation, from central equipment for heat generation and refrigeration through distribution systems to each conditioned space. Testing shall include measuring capacities and effectiveness of operational and control functions.
- C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response of building automation system controllers and sensors.
- D. The CxA, along with the Heating and Ventilating Contractors, Testing and Balancing Subcontractor, and the Controls Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.
- E. Tests will be performed using design conditions whenever possible.
- F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.
- G. The CxA may direct that set points be altered when simulating conditions is not practical.
- H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.
- I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and provide a deficiency report. After deficiencies are resolved, reschedule tests.
- J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.8 HVAC&R SYSTEMS, SUBSYSTEMS, AND EQUIPMENT TESTING PROCEDURES

- A. Equipment Testing and Acceptance Procedures: Testing requirements are specified in individual technical sections. Provide submittals, test data, inspector record, and certifications to the CxA.
- B. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Section 23 09 23 "Instrument and Control for HVAC". Assist the CxA with preparation of testing plans.

- C. Pipe system cleaning, flushing, hydrostatic tests, and chemical treatment: Test requirements are specified in piping specifications. Mechanical Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
 2. Description of equipment for flushing operations.
 3. Minimum flushing water velocity.
 4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.
- D. Refrigeration System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of chillers, cooling towers, refrigerant compressors and condensers, heat pumps, and other refrigeration systems. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.
- E. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of hydronic distribution systems and other distribution systems, including HVAC&R terminal equipment and unitary equipment.
- F. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems and sub-systems. The following equipment and systems shall be evaluated:
1. Building Automation System
 2. Chilled Water System
 3. Pumps
 4. Testing, Adjusting and Balancing
 5. Variable Frequency Drives (VFD)
- 3.9 DEFICIENCIES / NON-CONFORMANCE, COST OF RETESTING, FAILURE DUE TO MANUFACTURER DEFECT
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to deficiencies/non-conformance, cost of retesting, or failure due to manufacturer defect.
- 3.10 APPROVAL
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for approval procedures.
- 3.11 DEFERRED TESTING
- A. Refer to Section 01 91 13 "General Commissioning Requirements" for requirements pertaining to deferred testing.

END 23 08 00

SECTION 23 09 00 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes open protocol DDC control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls, lighting in new and existing facilities, generators, freezer, coolers and make-up water meter.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. BACnet: Ashrea Standard 135/2004 open protocol standards
- D. MS/TP: Master slave/token passing. BACnet standard for 485 communications
- E. PC: Personal computer.
- F. PID: Proportional plus integral plus derivative.
- G. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

1.4 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.

7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Water Temperature: Plus or minus 1 deg F (0.5 deg C).
 - b. Water Flow: Plus or minus 5 percent of full scale.
 - c. Water Pressure: Plus or minus 2 percent of full scale.
 - d. Space Temperature: Plus or minus 0.35 deg F (0.5 deg C).
 - e. Ducted Air Temperature: Plus or minus 0.35 deg F (0.5 deg C).
 - f. Outside Air Temperature: Plus or minus 0.35 deg F (1.0 deg C).
 - g. Dew Point Temperature: Plus or minus 0.35 deg F (1.5 deg C).
 - h. Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
 - i. Relative Humidity: Plus or minus 2 percent.
 - j. Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
 - k. Airflow (Terminal): Plus or minus 10 percent of full scale.
 - l. Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
 - m. Carbon Dioxide: Plus or minus 50 ppm.
 - n. Electrical: Plus or minus 5 percent of reading.

1.5 SUBMITTALS

- A. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
 1. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
 2. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
 3. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 1. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 2. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
 3. Wiring Diagrams: Power, signal, and control wiring.
 4. Details of control panel faces, including controls, instruments, and labeling.
 5. Written description of sequence of operation.
 6. Schedule of dampers including size, leakage, and flow characteristics.
 7. Schedule of valves including flow characteristics.
 8. DDC System Hardware:
 - a. Wiring diagrams for control units with termination numbers.
 - b. Schematic diagrams and floor plans for field sensors and control hardware.
 - c. Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.

9. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
 10. Controlled Systems:
 - a. Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
 - b. Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
 - c. Written description of sequence of operation including schematic diagram.
 - d. Points list.
- C. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135 and that system is Open Protocol.
- D. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals.
 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 3. Device address list.
 4. Printout of software application and graphic screens.
 5. Software license required by and installed for DDC workstations and control systems.
- E. Software Upgrade Kit: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- F. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Maintenance instructions and lists of spare parts for each type of control device and compressed-air station.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
- 1.6 QUALITY ASSURANCE
- A. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.
 - B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
 - C. Comply with ASHRAE 135 (BACnet) for DDC system components.
- 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.8 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment with Division 26 Section "Lighting Controls" to achieve compatibility with equipment that interfaces with that system.
- C. Coordinate equipment with Division 28 Section "Fire Detection and Alarm" to achieve compatibility with equipment that interfaces with that system.
- D. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.
- E. Coordinate equipment with Division 26 Section "Motor-Control Centers" to achieve compatibility with motor starters and annunciation devices.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 CONTROL SYSTEM

- A. Manufacturers:
 - 1. JCI.
 - 2. Automated Logic
 - 3. Reliable
- B. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.

2.3 DDC EQUIPMENT

- A. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation.
 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 - d. Software applications, scheduling, and alarm processing.
 - e. Testing and developing control algorithms without disrupting field hardware and controlled environment.
 3. Standard Application Programs:
 - a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
 - b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
 - c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
 - d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
 - e. Remote communications.
 - f. Maintenance management.
 - g. Units of Measure: Inch-pound.
 4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
 5. ASHRAE 135 – BACnet Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 6. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- B. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
 2. Stand-alone mode control functions operate regardless of network status. Functions include the following:
 - a. Global communications.
 - b. Discrete/digital, analog, and pulse I/O.
 - c. Monitoring, controlling, or addressing data points.
 3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

4. ASHRAE 135 – BACnet Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- C. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
1. Binary Inputs: Allow monitoring of on-off signals without external power.
 2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
 3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
 4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights.
 5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer.
 6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
 7. Universal I/Os: Provide software selectable binary or analog outputs.
- D. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
1. Output ripple of 5.0 mV maximum peak to peak.
 2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
 3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- E. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
1. Minimum dielectric strength of 1000 V.
 2. Maximum response time of 10 nanoseconds.
 3. Minimum transverse-mode noise attenuation of 65 dB.
 4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.4 SYSTEM SOFTWARE

- A. General:
1. Contractor shall provide all software required for efficient operation of all functions required by this specification. Software shall be modular in design for flexibility in expansion or revision of the system. Software shall, as a minimum, include:
 - a. Complete database entry.
 - b. Configuration of all application programs to provide the sequence of operation indicated.
 - c. Complete graphics package, including graphics floor plans and individual graphics, for each system.
 - d. Alarm limits and alarm messages for all critical and non-critical alarms.
 - e. Configuration of all reports and point summaries indicated.

2. System software shall be complete such that each control loop shall function as specified in the Sequence of Operation.
3. Building control system manufacturer shall be required to write the software program and test the operation of every control loop. A letter certifying that the system is ready for inspection shall be submitted to the engineer prior to the controllers being shipped to the field. The Engineer may at his option visit the contractor's office and witness proper operation of each control loop prior to shipping from the contractor's point of fabrication. The control contractor shall provide a means of simulating every input to the system as a requirement for debugging the software. Prior to shipping of the microprocessor controller, the debugged software shall be transmitted to the owner for approval.
4. After all field connections have been made and control power is available in the control panel, the owner shall be notified and the control system shall be energized. Any required reloading of the software shall be performed and start-up of the mechanical system and building control system shall commence.
5. Building control contractor shall be responsible for all necessary revisions to the software as required to provide a complete and workable system consistent with the letter and intent of the specification. All control performance criteria are specified in the Sequence of Operations section of the specification.
6. After the system has operated properly for 90 days following start-up of the final component of the heating and air conditioning systems, an as-built copy of the software shall be transmitted to the owner for permanent record purposes. Any software upgrading or enhancements to improve the system operation or as required for proper operation of the system during the first year of operation is the responsibility of the building control system contractor. Any changes to the software shall be immediately transmitted to the Owner.
7. The Building Network Controller shall incorporate the GUI (Graphical User Interface) via a standard web browser. Use of hardware keys or special licenses requirements to access the system with a browser is unacceptable. The Building controller will serve up the web pages on a standalone per building application for the intent that if the WAN is not working, an operator can access the system on site via the building internal network using an IP. A server computer will be located at the energy management office to supervise the remote panels and alarm if the communication is lost as well as any control function alarm. This server computer will also be the area of trending archives.
8. Software required to provide the initial operation routines shall not consume more than 70% of the programmable capability of the controller.
9. Software shall be provided in these five categories:
 - a. System executive software.
 - b. Software for user control over system configuration at the Central Site location, and by Maintenance Personnel in the field.
 - c. Facility monitoring functions.
 - d. Direct digital control.
 - e. Application software.
10. Each category of software shall consist of interactive software modules. Each module shall have an associated priority level and shall execute as determined by the program controller as defined in the real time operating system.
11. Building operator shall be able to communicate and direct all control functions through the use of a 2-button "mouse" operator interface to monitor and control all functions and sequences within the system.
12. Central site shall allow receipt of alarms and messages while in a functional mode other than energy management. I.e. incoming alarms shall be displayed while the operator is in a word processing, spreadsheet or other operating mode. The system must automatically switch from a non- energy management mode, respond to an alarm, and return to the exact position left in the previous functional mode.
13. Central site must be able to generate standard ASCII file formats to allow use with third-party software (**Microsoft Excel**) to generate and store owner-designed reports.

- B. Systems Software:
1. Central site shall display graphically, in up to 64 different colors, the following system information:
 - a. Floor plan maps shall show heating and cooling zones throughout the buildings in a range of colors which provide a visual display of temperature relative to their respective setpoints. The colors shall be updated dynamically as zones' comfort condition change. Locations of space sensors shall also be shown for each zone. Setpoint adjustment and color band displays shall be provided as specified.
 - b. Lighting floor plan maps shall show the status of each individual lighting circuit. When the lights are "on", the area served shall respond in a pre-selected color. When the lights are "off", the area served shall appear gray.
 - c. Mechanical system graphics shall show the type of mechanical system components serving any zone through the use of a pictorial representation of components. It shall also provide a current status of all I/O points being controlled and applicable to each piece of equipment including analog readouts in appropriate engineering units at appropriate locations on the graphic representation.
 - d. The following information shall be selected from a "pop- up" menu available on various graphics:
 - 1) Alarms.
 - 2) Messages.
 - 3) Module Status.
 - 4) Programming Parameters.
 - 5) Quit.
 - 6) Schedules.
 - 7) Schedule Graphs.
 - 8) Schedule Groups.
 - 9) Setpoints.
 - 10) Trends.
 - 11) Utilities.
 - e. Programming, scheduling and set-point changes shall be accessible for modification on each menu for the associated equipment. Operator shall be able to automatically download changes from the central site to the appropriate program for the equipment being controlled. Operator shall be able to upload information from the field modules to the central site.
 2. Input Format:
 - a. Allowable operators, as defined under user access, shall be able to control system functions by their inputs at an appropriate user terminal. Primary operator interface shall be via two button mouse.
 3. Verification of Operator Input:
 - a. System shall acknowledge all inputs as functions or commands to be performed. System's handling of operator inputs, such as requests to start a motor, output a log, change a time program, acknowledge an alarm, or do any of the other commands described in this specification, shall be in a similar format.
 4. Operator Commands:
 - a. All operator commands shall be in graphics data base and menu driven. After the operator selects the desired object item or menu, the system shall display either the status of selected object item or the allowable options available. Upon entry of a command to the point or points desired as described above, the system shall, before performing any command requested and any entered data. System shall include error monitoring software for user's input error.
 5. Output Format:
 - a. The system shall operate on a System Format basis, regardless of the manner or hardware configuration in which the data is acquired. A "system" shall consist of a logical grouping of data points, related to a piece of mechanical equipment, an energy distribution system, or an architectural area. For example, in some cases, it

- may be desired to display, as a single system, a space temperature with its associated air handling unit, and in other cases to display all space temperatures on a floor or in a building. The DDC shall allow such determinations to be made without regard to the physical hardware locations of a point or group of points. Likewise, the system shall accommodate future changes of system grouping and operations without field hardware changes.
- b. All displays and logs shall contain a header line indicating date, day-of-week, and time.
 - c. All output displays or logs of a point or group of points shall contain, as a minimum, the following information:
 - 1) Graphic presentation of the System.
 - 2) User name of point.
 - 3) Point descriptor.
 - 4) Current value/status.
 - 5) Associated engineering units.
 - 6) Alarm description.
 - d. User names, point descriptors, and engineering units shall be operator definable on a per point basis.
6. Set points:
- a. System shall utilize a contiguous band of colors each corresponding to actual zone temperatures relative to the desired heating and cooling setpoints. The ideal temperature shall be shown as a green color band. This color band corresponds to the dead band between the onset of mechanical heating or cooling. Temperatures warmer than ideal shall be shown in orange.
 - b. Temperatures cooler than ideal shall be blue. All alarm colors shall be in red.
 - c. System shall be capable of utilizing the mouse operator interface device to change individual zone temperature setpoints. The change shall be accomplished by pointing to a graphic temperature bar and by depressing a button, moving the mouse cursor to an increased or decreased temperature set-point within that zone. System shall also be capable of utilizing the mouse interface device or a conventional keyboard to change a numeric temperature set-point value instead of utilizing the graphic temperature bar. Floor plan graphic shall then be able to change colors on a zone by zone basis to reflect the actual temperature in each zone relative to the changed desired heating or cooling set-point.
 - d. System shall be capable of globally changing all setpoints. The global change capability shall be accessed via a "pop up menu" called by depressing a button on the mouse.
7. Graphic Structure and Hardware:
- a. The intent of the graphics is to ensure the operator is always aware of his position within the system as well as how to logically progress through the graphical hierarchy to select any desired graphic or other source of information. The GUI will be served as a web page and access from any computer without any special software or hardware keys. The building network controller will hold the graphics for standalone operation. A computer on site will not be acceptable to serve the graphics. The sever computer will have the ability to access the system for engineering from the owner, alarming archives and alarms, remote monitoring of the health of the communications to the field devices and to archive the trend collection data from the building controllers. The web pages will follow a minimum Graphical layout shall be as follows:
 - (1) Main greeting page will have links for all building monitored for quick access.
 - (2) Once a building is selected a picture of the building will be displayed along with a menu of all systems controlled from this section. There will also be links for the floor plans.

- (3) Once the floor plan has been chosen, the selected graphic page will display the architectural floor plan. This plan will have temperature readings and Setpoints of all VAV's within this floor. There will also be links or button depicting the location and equipment number that is serving that area. This link will hyperlink into the graphic of the AHU. The temperature and setpoint reading will hyperlink to the selected VAV graphic for further review. If the floor has too many VAV data readings to display for an easy reading the floor plan may be broken into sections so that the view is easily readable.
- (4) Graphical VAV – The VAV box will be a graphical representation of a VAV box. The data shown on the box will be as follows:
 - i. Box Flow
 - ii. Box Flow Trend hyperlink
 - iii. Box Flow Setpoint
 - iv. Box Flow Trend hyperlink
 - v. Box Flow Min Setpoint
 - vi. Box Flow Max Setpoint
 - vii. Box Flow Reheat Min Setpoint (if applicable)
 - viii. Reheat Stage Commands (if applicable)
 - ix. Supply Air Temperature (with reheat)
 - x. Room Setpoint
 - xi. Room Setpoint Trend hyperlink
 - xii. Room Temperature
 - xiii. Room Temperature Trend hyperlink
 - xiv. Room Humidity (If applicable)
 - xv. Room Humidity Trend hyperlink
 - xvi. Room Humidity Setpoint (if applicable)
 - xvii. Room Humidity Setpoint Trend hyperlink
 - xviii. All points above to show a different status color if overridden
- (5) Graphical AHU – The AHU will be a graphical representation of the physical air handling unit specified. The data will be located on the AHU as physically located on the unit. The data on the AHU will be as follows:
 - i. Schedule for Unit hyperlink – link to the scheduling editor
 - ii. Schedule for Ventilation hyperlink – link to the scheduling editor.
 - iii. Occupied/Unoccupied status for each schedule
 - iv. Fan command
 - v. Fan status
 - vi. Fan speed
 - vii. Fan VFD alarm
 - viii. Temperature sensors as specified in the control sequence of operation and trending points
 - ix. All setpoints as specified in the sequence of operation
 1. Example – VAV AHU will have a supply air temperature and setpoint
 - x. Supply air static and trend hyperlink
 - xi. Supply air static Setpoint and trend hyperlink
 - xii. Return air damper position
 - xiii. Outside air damper position
 - xiv. Outside air flow and trend hyperlink
 - xv. Outside air flow setpoint and trend hyperlink
 - xvi. Outside air heater command
 - xvii. Outside air heater setpoint

- xviii. Any misc points needed from a sequence of operation
- xix. All points above to show a different status color if overridden
- (6) Graphical Chiller plant – The plant will be a graphical representation of the physical chiller plant as specified and installed. The data will be located on the graphical screen as physically installed in the plant.
 - i. All Chiller interface data
 - ii. Enable/Disable of Chillers and isolation valves
 - iii. Primary pump command and status
 - iv. Secondary Pump command, status, speed, and general alarm from the VFD.
 - v. Flow meters
 - vi. Temperature sensors
- (7) Misc. Points and graphical screens
- b. Graphical representation of text on the screens – The text blocks will have an opposing color for easier reading
- c. Graphical representation of the trends – each point to be trended will have a icon next to the point being trended. This icon will hyperlink to the trending chart builder for the individual trend screen. A trend icon on the main building screen will be a trendchart builder. This trend builder will allow to select multiple trends from a list, pick whether recent trending data or archived (in the server), date range, etc. Then after selection the trend chart builder will compile the data and build the trend for viewing or exporting to a spread sheet. This all happens with a standard web browser.
- d. A text block for an overridable point shall be highlighted when a mouse is scrolled over an object. When the text block and or pint is overridden the graphical point will turn to a different color. This allows for easy viewing of which points are overridden on a graphic screen.
- 1)
- 8. User Access Restriction. Operator sign-on shall require an assignable password. Passwords shall have six (6) levels of system access **or user defined**:
 - a. Level 1 - Trainee: The level shall allow readout of data only. System shall display all operation data base.
 - b. Level 2 - Maintenance 1: This level shall allow all of Level 1 functions plus the changing of all schedules.
 - c. Level 3 - Maintenance 2: This level shall allow performance of Level 2 functions plus the changing of all set points.
 - d. Level 4 - Supervisor: This level shall allow performance of Level 3 functions plus the changing of all system parameters.
 - e. Level 5 - System Programmer: This level shall allow performance of Level 4 functions plus the modifying the system configuration.
 - f. Level 6 - System Manager: This level shall allow performance of Level 5 functions plus the changing of passwords.
- 9. Power Failure/Automatic Restart:
 - a. Power failures shall cause the system to go into an orderly shutdown with no loss of program memory.
 - b. Upon resumption of power, the system shall automatically restart and printout the time and date of the power failure and restoration at the Central Site. "Restart" program shall automatically restart affected field equipment. Operator shall be able to define an automatic power up time delay for each piece of equipment under control.
 - c. User Control Over System Configuration:
 - 1) Database Creation and Modification. All changes shall be done utilizing standard procedures and be capable of being done while the system is on-

- line and operational. The system shall allow changes to be made through the portable operator terminal and from the central site. To aid the user, instructive prompting software shall be provided.
- 2) System shall permit the operator, with proper password, to perform as a minimum the following:
 - a) Add and delete points.
 - b) Modify point parameters.
 - c) Create and modify control sequences.
 - d) Reconfigure application programs.
 - e) Add and/or modify graphics.
 - 3) All data points within the database shall be completely accessible as independent or dependent variables for custom programming, calculation, interlocking, or manipulation.
 - 4) Graphics Software:
 - a) Graphics software shall permit the easy construction of infinitely variable shapes and sizes through the use of the mouse pointing device.
 - b) A selection of 64 colors and various fill textures, line types and text styles shall all be accessible through the use of the mouse interface. The software shall resemble many of the computer aided design programs currently available and allow graphics to be easily moved, edited, added or deleted.
 - c) Graphics software shall be fully implemented and operational to accomplish the following:
 1. Create a new graphic picture.
 2. Modify a portion of a graphic picture.
 3. Delete a graphic picture, or any portion thereof.
 4. Call up a graphic picture.
 5. Cancel the display of a graphic picture.
 6. Assign conditions which automatically initiate the display.
 7. Overlay alphanumeric and graphics.
 8. Save the graphic picture.
 9. Display latest process data fully integrated with the graphic display
- d. Facility Management Functions:
- 1) Trend Logging:
 - a) System shall be able to trend and display either numerically or graphically any analog or digital points in the system.
 - b) System shall be able to simultaneously graphically display any two trended points within a module function block or any point in the module versus the outside air temperature, enthalpy or relative humidity.
 - c) Each field module shall be capable of storing the most recent 60 samples for each single trend point or the most recent 30 samples for each of two trended points from one module function block.
 - d) Each module shall be capable of automatically uploading on a daily basis all accumulated trend data to the central site for permanent storage on hard disk.
 - 2) Run Time:
 - a) System shall provide run time information for all digital output and input points on command from the operator. Maximum run time limits shall be operator definable and shall be capable of automatically issuing a **visual** when the run time maximum is exceeded. Operator shall be able to reset the run time accumulator.

- b) Run time hours and start time date shall be retained in non-volatile module memory.
- c) Each module shall be capable of automatically uploading all accumulated data to the central site for permanent storage on hard disk.
- 3) Alarm Conditions and Maintenance Messages:
 - a) Central site shall allow receipt of alarms and messages while in a functional mode other than energy management. i.e., Incoming alarms shall be displayed **and generate an audible alarm** while the operator is utilizing another mode such as word processing and allow the operator to automatically return to word processing after the alarm is received.
 - b) System shall distinguish between alarms and messages with alarms having a higher priority.
 - c) System shall be capable of calling up to three different remote locations to deliver an alarm or message **through E-Mail, E-Page or alphanumeric page**. Operator shall determine if alarms or messages are to be based on temperature limit, status or off-normal reporting.
 - d) System shall be capable of printing maintenance messages when run time accumulation maximum limits are exceeded.
 - e) Text for operator alarm and messages shall be operator definable. System shall be capable of storing at least 100 messages each of any length. Generic messages used for multiple points throughout the system shall only count as one message. In the event the central site is powered down, alarms shall be stored in the modules until the central site is restored.
 - f) Central site shall be capable of transferring all alarms to hard disk for storage.
- 4) Reports and Archiving:
 - a) Field modules shall be capable of calling the central site during off peak phone rate hours to automatically upload all current and accumulated data. This shall be delivered to the central site for printing and/or permanent storage on hard disk. The system shall further be capable of transferring hard disk information onto a CD or USB external drive for remote site storage.
 - b) System shall be capable of reporting and archiving the following information as a minimum:
 - 1. Outside air temperature history and degree day history.
 - 2. Electric demand and usage history.
 - 3. All trended points.
 - 4. All alarms and messages.
 - 5. Equipment runtime information.
 - c) The system shall also provide the following additional reports for which archiving is not applicable:
 - 1. All points summary.
 - 2. Building operating schedules.
 - 3. Printout of any graphic screen.
 - d) System shall be capable of providing all points summaries on a hierarchical basis. e.g., only the points associated with a particular graphic shall be selectable and printed. For example, if the operator is viewing an air handling unit (AHU), he may request an all points summary at this level and receive only the points associated with the AHU. If the building is being viewed and an all points summary selected, all building points will be listed. Similarly, the system shall print building operating schedules pertinent to the graphic level being viewed. e.g., if a zone or tenant zone group is being viewed on the

graphic display, then the system shall be capable of printing the building operating schedules for the zone or tenant zone group. If the entire building graphic is being viewed, the system shall be capable of printing schedules at the building level. All systems reports shall be capable to being viewed at the operators' terminal and printed at the operator's discretion.

- e. Direct Digital Control Software:
 - 1) System shall continuously perform DDC functions at the local DDC controller in a stand-alone mode. The operator shall be able to design and modify the control loops to meet the requirements of the system being operated. Operators shall use system provided displays for tuning of PID loops. These displays shall include the past three input variable values, the set point for the loop as well as the sample interval and the results of the proportional, integral and derivative effects of the final output.
 - 2) Each Controller shall perform the following functions:
 - a) Identify and report alarm conditions.
 - b) Execute DDC algorithms.
 - c) Execute all application programs indicated on the I/O Summary table.
 - d) Trend and store data.
 - 3) In the event of a Controller failure, all points under its control shall be commanded to the failure mode.
 - 4) All DDC software shall reside in the respective DDC Controller.
- f. Application Software:
 - 1) Application software shall be as required to produce the sequence of operation specified.

2.5 ELECTRONIC SENSORS

- A. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
- B. Temperature Sensors: 10K resistor style.
 - 1. Accuracy: Plus or minus 0.35 deg F (0.2 deg C) at calibration point.
 - 2. Wire: Twisted, shielded-pair cable.
 - 3. Insertion Elements in Ducts: Single point, 8 inches (200 mm) long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft. (0.84 sq. m).
 - 4. Averaging Elements in Ducts: 36 inches (915 mm) long, flexible; use where prone to temperature stratification or where ducts are larger than 10 sq. ft. (1 sq. m).
 - 5. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of 2-1/2 inches (64 mm).
 - 6. Room Sensor Cover Construction: Manufacturer's standard covers.
 - a. Set-Point Adjustment: Exposed but disable.
 - b. Set-Point Indication: Exposed.
 - c. Thermometer: Digital temperature display.
 - d. Color: Beige
 - e. Orientation: Vertical.
 - f. Occupancy Override: Exposed only for office and classrooms.
 - 7. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- C. Humidity Sensors: Bulk polymer sensor element.

1. Accuracy: 2 percent full range with linear output.
2. Room Sensor Range: 0 to 100 percent relative humidity.
3. Room Sensor Cover Construction: Manufacturer's standard covers.
 - a. Set-Point Adjustment: Concealed.
 - b. Set-Point Indication: Exposed.
 - c. Humidity: Digital humidity display
 - d. Color: Beige.
 - e. Orientation: Vertical.
4. Calibration: Single point.

D. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
 - a. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
 - b. Output: 4 to 20 mA.
 - c. Building Static-Pressure Range: 0- to 0.25-inch wg (0 to 62 Pa).
 - d. Duct Static-Pressure Range: 0- to 5-inch wg (0 to 1240 Pa).
2. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure; linear output 4 to 20 mA.
3. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig (1034-kPa) operating pressure and tested to 300-psig (2070-kPa); linear output 4 to 20 mA.
4. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

E. Room sensor accessories include the following:

1. Guards: Metal wire, tamperproof for sensors located in gymnasiums, locker room, corridors, cafeteria, media center and multipurpose rooms.

2.6 STATUS SENSORS

- A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg (0 to 1240 Pa).
- B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig (55 to 414 kPa), piped across pump.
- C. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
- D. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
- E. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.7 GAS DETECTION EQUIPMENT

- A. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of 23 to 130 deg F (minus 5 to plus 55 deg C) and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output, for wall mounting.

2.8 FLOW MEASURING STATIONS

- A. Duct Airflow Station: Thermal Dispersion Technology.

- 1. Manufacturers:

- a. Ebtron.
- b. Tekair.
- c. Or Approved Equal

- 2. Each measuring device shall consist of one or more multi-point measuring probes and single microprocessor-base transmitter. Each transmitter shall have an LCD display capable of displaying airflow and temperature. Airflow shall be field configurable to display as a velocity or volumetric rate. Each transmitter shall operate at 24V.

- 3. Each sensing point shall independently determine the airflow rate and temperature, which shall be equally weighted and average by the transmitter prior to the output. Devices, which average multiple non-linear sensing points signals, are not acceptable. Pitot tubes arrays are not acceptable.

- 4. The operation air flow range shall be 0 – 5,000 FPM.

- 5. The operation temperature range for the measuring probes shall be -20°F to 160°F.

- 6. Accuracy: Each independent airflow sensor shall have a laboratory accuracy of $\pm 2\%$ and each independent temperature sensor shall have a laboratory accuracy of $\pm 0.15^\circ\text{F}$.

- 7. The transmitter shall be capable of communicating with the host controls using the following interface options:

- a. Linear analog output signal: Field selectable, fuse protected and isolated, 0-10VDC and 4-20mA (4-wire).
- b. LonWorks Free Topology.

- 8.

- B. Pipe Flow Meter: Electromagnetic Flow Meter.

- 1. Manufacturer:

- a. Onicon.
- b. Or Approved Equal

- 2. Accuracy: $\pm 1.0\%$ of reading at calibration velocity.

- 3. Sensing Method: Electromagnetic sensing (no moving parts).

- 4. Pipe Size Range: 3" through 72".

- 5. Supply Voltage: 24 V AC/DC at 250 mA.

- 6. Liquid Temperature Range: 15°F to 250°F peak.

- 7. Operating Pressure: 400 psi.

2.9 ENERGY METER

- A. BTU Meter.

- 1. Manufacturer:

- a. Onicon
- b. Or Approved Equal
2. Accuracy: Differential temperature accuracy $\pm 0.15^{\circ}\text{F}$.
3. Memory: Non-volatile EEPROM memory retains all parameters and totalized values in the event of power loss.
4. Flow meter: Flow meter by Onicon. Flow meter shall meet the requirements of section 2.7.C on these specifications.
5. Temperature sensors: Solid state sensors.
6. Temperature Range: 32°F to 200°F .
7. Display: Alphanumeric LCD display total energy, total flow, energy rate, flow rate, supply temperature and return temperature.
8. Output Signal: LonWorks or BACnet.

2.10 THERMOSTATS

- A. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating of 125% of service equipment; with exposed set-point adjustment, 55 to 85 deg F (13 to 30 deg C) set-point range, and 2 deg F (1 deg C) maximum differential.

2.11 ACTUATORS

- A. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
 1. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 2. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
 3. Nonspring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 4. Spring-Return Motors for Valves Larger Than NPS 2-1/2 (DN 65): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
 5. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
 6. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
- B. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
 1. Manufacturers:
 - a. Belimo Aircontrols (USA), Inc.
 - b. Schneider Electric Dura Drive
 - c. Or Approved Equal

2. Valves: Size for torque required for valve close off at maximum pump differential pressure.
3. Dampers: Size for running torque calculated as follows:
 - a. Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
 - b. Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
 - c. Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft (49.6 kg-cm/sq. m) of damper.
 - d. Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
 - e. Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
 - f. Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
4. Coupling: V-bolt and V-shaped, toothed cradle.
5. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
6. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
7. Power Requirements (Two-Position Spring Return): 24-V ac.
8. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
9. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
10. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C).
11. Temperature Rating (Smoke Dampers): Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).
12. Run Time: 12 seconds open, 5 seconds closed.

2.12 CONTROL VALVES

- A. Manufacturers:
 1. Belimo.
 2. Schneider Electric
 3. Or Approved Equal
- B. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
- C. Butterfly Valves: 200-psig (1380-kPa), 150-psig (1034-kPa) maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
 1. Body Style: Wafer or Grooved.
 2. Disc Type: Nickel-plated ductile iron.
 3. Sizing: 1-psig (7-kPa) maximum pressure drop at design flow rate.
- D. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.

1. Rating: Class 125 for service at 125 psig (860 kPa) and 250 deg F (121 deg C) operating conditions.
2. Sizing: 3-psig (21-kPa) maximum pressure drop at design flow rate, to close against pump shutoff head.
3. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.

2.13 DAMPERS

- A. Dampers: AMCA-rated, opposed blade design; 0.108-inch- (2.8-mm-) minimum thick, galvanized-steel or 0.125-inch- (3.2-mm-) minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than 0.064-inch- (1.6-mm-) thick galvanized steel with maximum blade width of 8 inches (200 mm) and length of 48 inches (1220 mm).
1. Secure blades to 1/2-inch- (13-mm-) diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
 2. Operating Temperature Range: From minus 40 to plus 200 deg F (minus 40 to plus 93 deg C).
 3. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.
 4. Edge Seals, Low-Leakage Applications: Use replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 10 cfm per sq. ft. (50 L/s per sq. m) of damper area, at differential pressure of 4-inch wg (1000 Pa) when damper is held by torque of 50 in. x lbf (5.6 N x m); when tested according to AMCA 500D.

2.14 CONTROL CABLE

- A. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Data Communications Integrations."

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that power supply is available to control units and operator workstation.

3.2 INSTALLATION

- A. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- B. Connect and configure equipment and software to achieve sequence of operation specified.
- C. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches (1220 mm) above the floor.
1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- D. Install automatic dampers according to Division 23 Section "Air Duct Accessories."

- E. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- F. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC Piping and Equipment."
- G. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping."
- H.
- I. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.
- J. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling."

3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Install building wire and cable according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling."
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - 6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
 - 7. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

C. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

D. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

E. After start-up and calibration, Building Controls Contractor shall submit to the Engineer trend logs of all points on each system demonstrating stable and proper operation. The trend logs shall be as follows:

1. 24 hour period at 15 minutes intervals.
2. 3 hour start-up period at 5 minute intervals.
3. A total of two sets covering two days during each period are required.

3.5 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.

4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 percent of span.
 - b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
 5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
 - b. Manually operate flow switches to verify that they make or break contact.
 6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
 7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
 8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
 9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
 10. Provide diagnostic and test instruments for calibration and adjustment of system.
 11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
- B. Adjust initial temperature and humidity set points.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 09 00

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Chilled-water piping.
 - 2. Makeup-water piping.
 - 3. Condensate-drain piping.
 - 4. Air-vent piping.

1.3 DEFINITIONS

- A. PTFE: Polytetrafluoroethylene.

1.4 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Chilled-Water Piping: 125 psig at 200 deg F.
 - 2. Makeup-Water Piping: 80 psig at 150 deg F.
 - 3. Condensate-Drain Piping: 150 deg F.
 - 4. Air-Vent Piping: 200 deg F.

1.5 SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air control devices.
 - 3. Chemical treatment.
 - 4. Hydronic specialties.
- B. Welding certificates.
- C. Field quality-control test reports.

- D. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
- E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.6 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.7 EXTRA MATERIALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
- B. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
- D. Wrought-Copper Unions: ASME B16.22.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

- C. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.

- D. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Anvil International, Inc.
 - b. Grinnell.
 - c. Victaulic.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Ductile- or malleable-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

- E. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.

- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

- D. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BA9-1, silver alloy for joining copper with bronze or steel.

- E. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

- F. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

- B. Dielectric Unions:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Hart Industries International, Inc.
 - d. Jomar International Ltd.
 - e. Matco-Norca, Inc.
 - f. McDonald, A. Y. Mfg. Co.
 - g. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - h. Wilkins; a Zurn company.

 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

- C. Dielectric Flanges:
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Capitol Manufacturing Company.
 - b. Central Plastics Company.
 - c. Matco-Norca, Inc.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - e. Wilkins; a Zurn company.

 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.5 VALVES

- A. Gate, Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."

- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Division 23 Section "Instrumentation and Control for HVAC."

- C. Bronze, Calibrated-Orifice, Balancing Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Gerand Engineering Co.
 - e. Griswold Controls.
 - f. Taco.
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armstrong Pumps, Inc.
 - b. Bell & Gossett Domestic Pump; a division of ITT Industries.
 - c. Flow Design Inc.
 - d. Gerand Engineering Co.
 - e. Griswold Controls.
 - f. Taco.
 - g. Tour & Andersson; available through Victaulic Company.
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.
11. Maximum Operating Temperature: 250 deg F.

2.6 AIR CONTROL DEVICES

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Amtrol, Inc.
 2. Armstrong Pumps, Inc.

3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

C. Diaphragm-Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 375 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. In-Line Air Separators:

1. Tank: One-piece cast iron with an integral weir constructed to decelerate system flow to maximize air separation.
2. Maximum Working Pressure: Up to 175 psig.
3. Maximum Operating Temperature: Up to 300 deg F.

2.7 CHEMICAL TREATMENT

A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves.

1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.8 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.

3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.

2.9 HPF CLOSED LOOP FILTER

- A. Filter shall be compatible with hydronic system chemical treatment. System shall have automatic backwash. Maximum water temperature 110°F and maximum pressure 120 psi. Media shall be able to remove suspended particles down to 5 micron.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Chilled-water piping, aboveground, NPS 2 and smaller, shall be the following:
 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- B. Chilled-water piping, aboveground, NPS 2-1/2 and larger, shall be any of the following:
 1. Schedule 40 steel pipe, wrought-steel fittings and wrought-cast or forged-steel flanges and flange fittings, and welded and flanged joints.
 2. Schedule 40 steel pipe; grooved, mechanical joint coupling and fittings; and grooved, mechanical joints.
- C. Makeup-water piping installed aboveground shall be the following:
 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- D. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- E. Air-Vent Piping:
 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.2 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- C. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.3 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, **NPS 3/4** ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

- T. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- U. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Division 23 Section "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Division 23 Section "Escutcheons for HVAC Piping."

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 - 6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
 - 7. NPS 4: Maximum span, 12 feet; minimum rod size, 1/2 inch.
 - 8. NPS 6: Maximum span, 12 feet; minimum rod size, 1/2 inch.
 - 9. NPS 8: Maximum span, 12 feet; minimum rod size, 5/8 inch.
 - 10. NPS 10: Maximum span, 12 feet; minimum rod size, 3/4 inch.
 - 11. NPS 12: Maximum span, 12 feet; minimum rod size, 7/8 inch.
 - 12. NPS 14: Maximum span, 12 feet; minimum rod size, 1 inch.
 - 13. NPS 16: Maximum span, 12 feet; minimum rod size, 1 inch.
 - 14. NPS 18: Maximum span, 12 feet; minimum rod size, 1-1/4 inches.
 - 15. NPS 20: Maximum span, 12 feet; minimum rod size, 1-1/4 inches.
- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 - 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- H. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings.

3.6 HYDRONIC SPECIALTIES INSTALLATION

- A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
- B. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- D. Install bypass chemical feeders in each hydronic system where indicated, in upright position with top of funnel not more than 48 inches above the floor. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Install NPS 3/4 pipe from chemical feeder drain, to nearest equipment drain and include a full-size, full-port, ball valve.
- E. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.
- F. Install HPF filter in each chilled water hydronic system in the upright position. . Install feeder in minimum NPS 1bypass line, from main with full-size, full-port, ball valve in the main between bypass connections. Installed make up water line with a full port, ball valve.

3.7 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."

3.8 CHEMICAL TREATMENT

- A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the following water characteristics:
 - 1. pH: 9.0 to 10.5.
 - 2. "P" Alkalinity: 100 to 500 ppm.
 - 3. Boron: 100 to 200 ppm.
 - 4. Corrosion Inhibitor:
 - a. Sodium Nitrate: 1000 to 1500 ppm.
 - b. Molybdate: 200 to 300 ppm.
 - c. Chromate: 200 to 300 ppm.
 - d. Sodium Nitrate Plus Molybdate: 100 to 200 ppm each.
 - e. Chromate Plus Molybdate: 50 to 100 ppm each.
 - 5. Soluble Copper: Maximum 0.20 ppm.
 - 6. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
 - 7. Total Suspended Solids: Maximum 10 ppm.
 - 8. Ammonia: Maximum 20 ppm.
 - 9. Free Caustic Alkalinity: Maximum 20 ppm.
 - 10. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
 - b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
 - c. Nitrate Reducers: 100 organisms/ml.
 - d. Sulfate Reducers: Maximum 0 organisms/ml.
 - e. Iron Bacteria: Maximum 0 organisms/ml.
- B. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water.
- C. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

3.9 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.

3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 100 psig. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings

END OF SECTION 23 21 13

SECTION 23 21 16 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes special-duty valves and specialties for the following:
 - 1. Chilled-water piping.
 - 2. Condensate-drain piping.
 - 3. Air-vent piping.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves: Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air-control devices.
 - 3. Hydronic specialties.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Chilled-Water Piping: 125 psig (860 kPa) at 200 deg F (93 deg C).
 2. Makeup-Water Piping: 80 psig (552 kPa) at 150 deg F (66 deg C).
 3. Condensate-Drain Piping: 150 deg F (66 deg C).
 4. Air-Vent Piping: 200 deg F (93 deg C).
 5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

- A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Section 23 05 23 "General-Duty Valves for HVAC Piping.
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 23 09 00 "Instrumentation and Control for HVAC."
- C. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett Domestic Pump.
 - b. Flow Design Inc.
 - c. Gerand Engineering Co.
 - d. Griswold Controls.
 - e. Taco.
 2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Plug: Resin.
 5. Seat: PTFE.
 6. End Connections: Threaded or socket.
 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 8. Handle Style: Lever, with memory stop to retain set position.
 9. CWP Rating: Minimum 125 psig (860 kPa).
 10. Maximum Operating Temperature: 250 deg F (121 deg C).
- D. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Bell & Gossett Domestic Pump.
 - b. Flow Design Inc.
 - c. Griswold Controls.
 - d. Taco.
 2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Stem Seals: EPDM O-rings.

5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig (860 kPa).
11. Maximum Operating Temperature: 250 deg F (121 deg C).

E. Diaphragm-Operated, Pressure-Reducing Valves: ASME labeled.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Bell & Gossett Domestic Pump.
 - c. Conbraco Industries, Inc.
 - d. Spence Engineering Company, Inc.
 - e. Watts Regulator Co.
2. Body: Bronze or brass.
3. Disc: Glass and carbon-filled PTFE.
4. Seat: Brass.
5. Stem Seals: EPDM O-rings.
6. Diaphragm: EPT.
7. Low inlet-pressure check valve.
8. Inlet Strainer: stainless steel, removable without system shutdown.
9. Valve Seat and Stem: Noncorrosive.
10. Valve Size, Capacity, and Operating Pressure: Selected to suit system in which installed, with operating pressure and capacity factory set and field adjustable.

F. Automatic Flow-Control Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
 - c. Nexus Valve, Inc.
2. Body: Brass or ferrous metal.
3. Piston and Spring Assembly: Stainless steel, tamper proof, self-cleaning, and removable.
4. Combination Assemblies: Include bronze or brass-alloy ball valve.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig (1207 kPa).
9. Maximum Operating Temperature: 200 deg F (93 deg C).

2.3 AIR-CONTROL DEVICES

A. Manual Air Vents:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Nexus Valve, Inc.
 - e. Taco, Inc.
 2. Body: Bronze.
 3. Internal Parts: Nonferrous.
 4. Operator: Screwdriver or thumbscrew.
 5. Inlet Connection: NPS 1/2 (DN 15).
 6. Discharge Connection: NPS 1/8 (DN 6).
 7. CWP Rating: 150 psig (1035 kPa).
 8. Maximum Operating Temperature: 225 deg F (107 deg C).
- B. Automatic Air Vents:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Nexus Valve, Inc.
 - e. Taco, Inc.
 2. Body: Bronze or cast iron.
 3. Internal Parts: Nonferrous.
 4. Operator: Noncorrosive metal float.
 5. Inlet Connection: NPS 1/2 (DN 15).
 6. Discharge Connection: NPS 1/4 (DN 8).
 7. CWP Rating: 150 psig (1035 kPa).
 8. Maximum Operating Temperature: 240 deg F (116 deg C).
- C. Diaphragm-Type Expansion Tanks:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Taco, Inc.
 2. Tank: Welded steel, rated for 125-psig (860-kPa) working pressure and 375 deg F (191 deg C) maximum operating temperature. Factory test after taps are fabricated and supports installed and are labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 3. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 4. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

D. Tangential-Type Air Separators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Taco, Inc.
2. Tank: Welded steel; ASME constructed and labeled for 125-psig (860-kPa) minimum working pressure and 375 deg F (191 deg C) maximum operating temperature.
3. Air Collector Tube: Perforated stainless steel, constructed to direct released air into expansion tank.
4. Tangential Inlet and Outlet Connections: Threaded for NPS 2 (DN 50) and smaller; flanged connections for NPS 2-1/2 (DN 65) and larger.
5. Blowdown Connection: Threaded.
6. Size: Match system flow capacity.

E. Air Purgers:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Amtrol, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 - d. Taco, Inc.
2. Body: Cast iron with internal baffles that slow the water velocity to separate the air from solution and divert it to the vent for quick removal.
3. Maximum Working Pressure: 150 psig (1035 kPa).
4. Maximum Operating Temperature: 250 deg F (121 deg C).

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body:
 - a. ASTM A 536, Grade 65-45-12, ductile iron with grooved joint coupled cover.
 - b. ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged or grooved ends for NPS 2-1/2 (DN 65) and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent total free area.
4. CWP Rating: 300 psig (2065 kPa).
5. Comparable to: Victaulic Style 732 / W732.

B. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch (20-mm) misalignment.

4. CWP Rating: 150 psig (1035 kPa).
5. Maximum Operating Temperature: 250 deg F (121 deg C).

C. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.
4. CWP Rating: 250 psig.
5. Maximum Operating Temperature: 250 deg F (121 deg C).

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated-orifice, balancing or automatic balancing valves at each branch connection to return main.
- C. Install calibrated-orifice or automatic, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting.
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- D. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.

END OF SECTION 23 21 16

SECTION 23 31 13 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Sealants and gaskets.
 - 5. Hangers and supports.

1.3 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Structural Performance: Duct hangers and supports shall withstand the effects of gravityloads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:
 - 1. Sealants and gaskets.
- B. Shop Drawings:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory- and shop-fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.

8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.

C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations for selecting hangers and supports.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
2. Suspended ceiling components.
3. Structural members to which duct will be attached.
4. Size and location of initial access modules for acoustical tile.
5. Penetrations of smoke barriers and fire-rated construction.
6. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."

- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90 .
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- D. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches .

2.3 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. VOC: Maximum 75 g/L (less water).
 7. Maximum Static-Pressure Class: 10-inch wg , positive and negative.
 8. Service: Indoor or outdoor.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- C. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
 2. Type: S.
 3. Grade: NS.
 4. Class: 25.
 5. Use: O.
 6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- E. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
 2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
 3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.4 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

- C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 , "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
- F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
- G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- H. Trapeze and Riser Supports:
 - 1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 - 2. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
 - 3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round and flat-oval ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a clearance of 1 inch , plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal

flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches .

- K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 ADDITIONAL INSTALLATION REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
- C. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

3.4 DUCT SEALING

- A. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

3.5 HANGER AND SUPPORT INSTALLATION

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

- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 - 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 - 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1 , "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet .
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.6 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.8 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:
 - 1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
 - 2. Test the following systems:
 - a. Supply Ducts with a Pressure Class of 3-Inch wg or Higher: Test representative duct sections totaling no less than 100 percent of total installed duct area for each designated pressure class.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

C. Duct system will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.9 START UP

- A. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

3.10 DUCT SCHEDULE

A. Supply Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive 1-inch wg.
- b. Minimum SMACNA Seal Class: C.
- c. SMACNA Leakage Class for Rectangular: 24.
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Constant-Volume Air-Handling Units:

- a. Pressure Class: Positive 2-inch wg .
- b. Minimum SMACNA Seal Class: B.
- c. SMACNA Leakage Class for Rectangular: 12.
- d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Variable-Air-Volume Air-Handling Units:

- a. Pressure Class: Positive 3-inch wg .
- b. Minimum SMACNA Seal Class: B.
- c. SMACNA Leakage Class for Rectangular: 6.
- d. SMACNA Leakage Class for Round and Flat Oval: 3.

B. Return Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:

- a. Pressure Class: Positive or negative 1-inch wg .
- b. Minimum SMACNA Seal Class: C.
- c. SMACNA Leakage Class for Rectangular: 24.
- d. SMACNA Leakage Class for Round and Flat Oval: 12.

2. Ducts Connected to Air-Handling Units:

- a. Pressure Class: Positive or negative 2-inch wg.
- b. Minimum SMACNA Seal Class: B.
- c. SMACNA Leakage Class for Rectangular: 12.
- d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Exhaust Ducts:

1. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
 - a. Pressure Class: Negative 1-inch wg .
 - b. Minimum SMACNA Seal Class: C if negative pressure, and A if positive pressure.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
 - a. Exposed to View: Type 304, stainless-steel sheet, No. 4 finish.
 - b. Concealed: Carbon-steel sheet.
 - c. Welded seams and joints.
 - d. Pressure Class: Positive or negative 3-inch wg .
 - e. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - f. SMACNA Leakage Class: 3.
3. Ducts Connected to Dishwasher Hoods:
 - a. Type 304, stainless-steel sheet.
 - b. Exposed to View: No. 4 finish.
 - c. Concealed: No. 2D finish.
 - d. Welded seams and flanged joints with watertight EPDM gaskets.
 - e. Pressure Class: Positive or negative 3-inch wg .
 - f. Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
 - g. SMACNA Leakage Class: 3.

D. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:

1. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
 - a. Pressure Class: Positive or negative 1-inch wg .
 - b. Minimum SMACNA Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
2. Ducts Connected to Air-Handling Units:
 - a. Pressure Class: Positive or negative 2-inch wg .
 - b. Minimum SMACNA Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.

E. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.
2. Stainless-Steel Ducts:
 - a. Exposed to Airstream: Match duct material.

- b. Not Exposed to Airstream: Match duct material.

F. Elbow Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower:
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm :
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
2. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
3. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Radius-to Diameter Ratio: 1.5.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Standing seam.

G. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.
 - b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm : Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

BITHLO COMMUNITY CENTER
HVAC REPLACEMENT

SECTION 233113
METAL DUCTS

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SECTION 23 33 00 - DUCT ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Manual-volume dampers.
 - 2. Flexible connectors.
 - 3. Flexible ducts.
 - 4. Duct accessory hardware.
 - 5. Flange Connectors
 - 6. Duct Mounted Access Door

1.3 SUBMITTALS

- A. Product Data: For the following:
 - 1. Manual-volume dampers.
 - 2. Flexible connectors.
 - 3. Flexible ducts.
 - 4. Duct accessory hardware.
 - 5. Flange Connector
 - 6. Duct Mounted Access Door
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loadings, required clearances, method of field assembly, components, location, and size of each field connection. Detail the following:
 - 1. Special fittings and manual- and automatic-volume-damper installations.
- C. Product Certificates: Submit certified test data on dynamic insertion loss; self-noise power levels; and airflow performance data, static-pressure loss, dimensions, and weights.

1.4 QUALITY ASSURANCE

- A. NFPA Compliance: Comply with the following NFPA standards:
 - 1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
 - 2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

PART 2 - PRODUCTS

2.1 SHEET METAL MATERIALS

- A. Galvanized, Sheet Steel: Lock-forming quality; ASTM A 653, G90 coating designation; mill-phosphatized finish for surfaces of ducts exposed to view.
- B. Carbon-Steel Sheets: ASTM A 366/A 366M, cold-rolled sheets, commercial quality, with oiled, exposed matte finish.
- C. Aluminum Sheets: ASTM B 209, Alloy 3003, Temper H14, sheet form; with standard, one-side bright finish for ducts exposed to view and mill finish for concealed ducts.
- D. Extruded Aluminum: ASTM B 221, Alloy 6063, Temper T6.
- E. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized, sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for 36-inch length or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.2 MANUAL-VOLUME DAMPERS

- A. General: Factory fabricated with required hardware and accessories. Stiffen damper blades for stability. Include locking device to hold single-blade dampers in a fixed position without vibration. Close duct penetrations for damper components to seal duct consistent with pressure class.
 - 1. Pressure Classifications of 3-Inch wg or Higher: End bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
- B. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
- C. Standard Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, standard leakage rating, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 16 gauge, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 16 gauge, galvanized, sheet steel.
 - 3. Blade Axles: Plated steel.
 - 4. Tie Bars and Brackets: Galvanized steel.
- D. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
- E. Low-Leakage Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, and suitable for horizontal or vertical applications.
 - 1. Steel Frames: Hat-shaped, galvanized, sheet steel channels, minimum of 16 gauge, with mitered and welded corners; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - 2. Roll-Formed Steel Blades: 16 gauge, galvanized, sheet steel, air foil shaped.
 - 3. Blade Seals: Neoprene.
 - 4. Blade Axles: Plated steel.
 - 5. Tie Bars and Brackets: Galvanized steel.

- F. High-Performance Volume Dampers: Multiple- or single-blade, parallel- or opposed-blade design as indicated, low-leakage rating, with linkage outside airstream, and suitable for horizontal or vertical applications.
 - 1. Aluminum Frames: Hat-shaped, 0.125-inch thick, extruded-aluminum channels; frames with flanges where indicated for attaching to walls; and flangeless frames where indicated for installing in ducts.
 - 2. Extruded-Aluminum Blades: Minimum of 0.081-inch thick, 6063T extruded aluminum.
 - 3. Blade Seals: Dual-durometer vinyl on blade edges; metallic compression on jambs.
 - 4. Blade Axles: Plated steel.
 - 5. Tie Bars and Brackets: Aluminum.
- G. Jackshaft: 1-inch diameter, galvanized steel pipe rotating within a pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
 - 1. Length and Number of Mountings: Appropriate to connect linkage of each damper of a multiple-damper assembly.
- H. Damper Hardware: Zinc-plated, die-cast core with dial and handle made of 3/32-inch thick zinc-plated steel, and a 3/4-inch hexagon locking nut. Include center hole to suit damper operating-rod size. Include elevated platform for insulated duct mounting.

2.3 FLEXIBLE CONNECTORS

- A. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 1.
- B. Standard Metal-Edged Connectors: Factory fabricated with a strip of fabric 3-1/2 inches wide attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts.
- C. Conventional, Indoor System Flexible Connector Fabric: Glass fabric double coated with polychloroprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp, and 360 lbf/inch in the filling.
- D. Conventional, Outdoor System Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber, weatherproof coating resistant to the sun's ultraviolet rays and ozone environment.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 530 lbf/inch in the warp, and 440 lbf/inch in the filling.

2.4 FLEXIBLE DUCTS

- A. General: Comply with UL 181, Class 1.
- B. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing 1-1/2-inch thick, glass-fiber insulation around a continuous inner liner.
 - 1. Reinforcement: Steel-wire helix encapsulated in inner liner.
 - 2. Outer Jacket: Glass-reinforced, silver Mylar with a continuous hanging tab, integral fibrous-glass tape, and nylon hanging cord.
 - 3. Inner Liner: Polyethylene film.
 - 4. Flexible Duct: Technaflex, Flexmaster.

- C. Flexible Duct Acoustical: Factory-fabricated insulated round duct with an outer jacket enclosing 1-1/2 inch thick, glass-fiber insulation around an acoustically transparent nylon inner liner.
 - 1. Reinforcement: Steel-wire helix encapsulated in inner liner.
 - 2. Outer Jacket: Glass-reinforced, silver Mylar with a continuous hanging tab, integral fibrous-glass tape, and nylon hanging cord.
 - 3. Inner Liner: Acoustically transparent nylon fabric.
 - 4. Acoustical flexible duct shall be Flexmaster Type 6 or equal.
- D. Pressure Rating: 6-inch wg positive, 1/2-inch wg negative.

2.5 ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments, and length to suit duct insulation thickness.
- B. Splitter Damper Accessories: Zinc-plated damper blade bracket; 1/4-inch, zinc-plated operating rod; and a duct-mounted, ball-joint bracket with flat rubber gasket and square-head set screw.
- C. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 to 18 inches to suit duct size.
- D. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

2.6 FLANGE CONNECTORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Ductmate Industries, Inc.
 - 2. Nexus PDQ; Division of Shilco Holdings Inc.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Add-on or roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gage and Shape: Match connecting ductwork.

2.7 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Elgen Manufacturing.
 - 5. Flexmaster U.S.A., Inc.
 - 6. Greenheck Fan Corporation.
 - 7. McGill AirFlow LLC.

8. Nailor Industries Inc.
 9. Pottorff.
 10. Ventfabrics, Inc.
 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch (25-by-25-mm)butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches (300 mm) Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches (460 mm) Square: Continuous and two sash locks.
 - c. Access Doors up to 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.
 - d. Access Doors Larger Than 24 by 48 Inches (600 by 1200 mm): Continuous and two compression latches with outside and inside handles.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for metal ducts and NAIMA's "Fibrous Glass Duct Construction Standards" for fibrous-glass ducts.
- B. Install backdraft dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 1. Install steel volume dampers in steel ducts.
 2. Install aluminum volume dampers in aluminum ducts.
- D. Set dampers to fully open position before testing, adjusting, and balancing.
- E. Install volume dampers in lined duct; avoid damage to and erosion of duct liner.
- F. Provide test holes at fan inlet and outlet and elsewhere as indicated.
- G. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:

1. On both sides of duct electric heater.
2. Upstream from duct filters.
3. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
4. At each change in direction and at maximum 50-foot (15-m) spacing.
5. Control devices requiring inspection.
6. Elsewhere as indicated.

H. Access Door Sizes:

1. One-Hand or Inspection Access: 8 by 5 inches (200 by 125 mm).
2. Two-Hand Access: 12 by 6 inches (300 by 150 mm).
3. Head and Hand Access: 18 by 10 inches (460 by 250 mm).
4. Head and Shoulders Access: 21 by 14 inches (530 by 355 mm).
5. Body Access: 25 by 14 inches (635 by 355 mm).
6. Body plus Ladder Access: 25 by 17 inches (635 by 430 mm).

I. Install flexible connectors to connect ducts to equipment.

J. Label access doors according to Division 23 Section "Mechanical Identification."

K. Ductwork flexible connectors are not required for internally isolated equipment.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate remote damper operators to verify full range of movement of operator and damper.

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PART 4 -

SECTION 23 34 23 - POWER VENTILATORS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

- 1. Centrifugal roof ventilators.
- 2. In-line centrifugal fans.

1.3 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.
- B. Operating Limits: Classify according to AMCA 99.

1.4 SUBMITTALS

- A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
- B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 - 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
- C. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Roof framing and support members relative to duct penetrations.

2. Size and location of initial access modules for acoustical tile.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standard: Power ventilators shall comply with UL 705.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.7 COORDINATION

A. Coordinate size and location of structural-steel support members.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 7 Section "Roof Accessories."

1.8 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Belts: One set(s) for each belt-driven unit.

PART 2 - PRODUCTS

2.1 CENTRIFUGAL ROOF VENTILATORS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Greenheck.
 - 2. Loren Cook Company.
 - 3. Penn Ventilation.
- B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone.
 - 1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector.
 - 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
 - 1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 - 4. Fan and motor isolated from exhaust airstream.
- F. Accessories:
 - 1. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 - 2. Bird Screens: Removable, **1/2-inch** mesh, aluminum or brass wire.
- G. Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch**- thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch** wood nailer. Size as required to suit roof opening and fan base.
 - 1. Configuration: Self-flashing without a cant strip, with mounting flange.
 - 2. Overall Height: **12 inches**.

2.2 IN-LINE CENTRIFUGAL FANS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide the product indicated on Drawings or a comparable product by one of the following:
 - 1. Greenheck.
 - 2. Loren Cook Company.
 - 3. Penn Ventilation.
- B. Description: In-line, direct or belt-driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.

- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- G. Accessories:
 - 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
 - 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 - 3. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

2.3 MOTORS

- A. Comply with requirements in Division 23 Section "Motors."
- B. Enclosure Type: Totally enclosed, fan cooled.

2.4 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 Section "Roof Accessories" for installation of roof curbs.
- C. Install units with clearances for service and maintenance.
- D. Label units according to requirements specified in Division 23 Section "Mechanical Identification."

3.2 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct

connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Duct Accessories."

- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Section "Grounding and Bonding."
- D. Connect wiring according to Division 26 Section "Conductors and Cables."

3.3 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that cleaning and adjusting are complete.
 - 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 - 5. Adjust belt tension.
 - 6. Adjust damper linkages for proper damper operation.
 - 7. Verify lubrication for bearings and other moving parts.
 - 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 - 9. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 10. Shut unit down and reconnect automatic temperature-control operators.
 - 11. Remove and replace malfunctioning units and retest as specified above.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

END OF SECTION 23 34 23

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SECTION 23 36 00 - AIR TERMINALS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Single-duct air terminals.

1.3 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.
 - 2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- C. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- D. Comply with NFPA 70 for electrical components and installation.

1.4 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

- A. Section 23 09 00 – DDC Control Systems: Thermostats and Control Components.
- B.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide air terminals by one of the following:
 - 1.
 - 2. Carrier Corp.
 - 3. Environmental Technologies.

4. Titus.
5. Trane Co. (The).
6. Price
7. Metalaire.

2.2 SINGLE-DUCT AIR TERMINALS

- A. Configuration: Volume-damper assembly inside unit casing. Locate control components inside protective metal shroud.
- B. Casings: Steel sheet metal of the following minimum thicknesses:
 1. Upstream Pressure Side: 0.0239-inch steel.
 2. Downstream Pressure Side: 0.0179-inch steel.
- C. Casing Lining: Minimum of 1-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation; 1.5-lb/cu. ft. density, complying with NFPA 90A requirements and UL 181 erosion requirements. Secure lining to prevent delamination, sagging, or settling.
 1. Coat liner surfaces and edges with erosion-resistant coating or cover with perforated metal.
- D. Plenum Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
- E. Plenum Air Outlets: S-slip and drive connections.
- F. Access: Removable panels to permit access to dampers and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- G. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings.
 1. Maximum Damper Leakage: 2 percent of nominal airflow at 1-inch wg inlet static pressure.
 2. Damper Position: Normally closed.
- H. Attenuator Section: Line with 2-inch-thick, neoprene- or vinyl-coated, fibrous-glass insulation.
- I. Multioutlet Attenuator Section: With collars of sizes shown on plans; each with locking butterfly balancing damper.
- J. Round Outlet: Discharge collar matching inlet size.
- K. Electric Heating Coil: Slip-in type, open-coil design with integral control box factory wired and installed. Include the following features:
 1. Primary and secondary overtemperature protection.
 2. Minimum airflow switch.
 3. Magnetic contactor for each step of control.
- L. Controls: Factory mount, wire, and test controls damper operator and other devices compatible with temperature controls specified in Section 23 09 00.
 1. Velocity Controller: Multiple-point averaging sensors, factory calibrated to minimum and maximum air volumes, field adjustable; maintains constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inches wg.

- M. Provide units with factory installed 24V transformer.

2.3 SOURCE QUALITY CONTROL

- A. Testing Requirements: Test and rate air terminals according to ARI 880, "Industry Standard for Air Terminals."
- B. Identification: Label each air terminal with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminals level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards; and maintain sufficient clearance for normal service and maintenance.
- B. Connect ductwork to air terminals according to Division 23 ductwork Sections.

3.2 CONNECTIONS

- A. Install piping adjacent to air terminals to allow service and maintenance.
- B. Electrical: Comply with applicable requirements in Division 26 Sections.
- C. Ground equipment.
 - 1. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
 - 2.

3.3 FIELD QUALITY CONTROL

- A. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

3.5 COMMISSIONING

- A. Verify that installation of each air terminal is according to the Contract Documents.

- B. Check that inlet duct connections are as recommended by air terminal manufacturer to achieve proper performance.
- C. Check that controls and control enclosure are accessible.
- D. Verify that control connections are complete.
- E. Check that nameplate and identification tag are visible.
- F. Verify that controls respond to inputs as specified.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules related to startup and shutdown, troubleshooting, servicing, and preventive maintenance.
 - 2. Review data in the maintenance manuals. Refer to Division 1 Section "Contract Closeout."
 - 3. Review data in the maintenance manuals. Refer to Division 1 Section "Operation and Maintenance Data."
 - 4. Schedule training with Owner, through Architect, with at least 7 days' advance notice.

END OF SECTION 23 36 00

SECTION 23 73 13 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Constant-air-volume, single-zone air-handling units.
 - 2. Variable-air-volume, single-zone air-handling units.

1.3 PERFORMANCE REQUIREMENTS

- A. Air leakage shall be determined at 1.50 times maximum casing static pressure up to 8 inches 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 111 Leakage Class.
- B. Casing performance - Casing air leakage shall not exceed leak class 6 (CL = 6) per ASHRAE 111 at specified casing pressure, where maximum casing leakage (cfm/100 ft² of casing surface area) = CL X P^{0.65}.
- C. Unit casing (wall/floor/pressure bulkhead roof panels and doors) shall be able to withstand up to 1.5 times design static pressure up to +8" w.g. in all positive pressure sections and -8" w.g. in all negative pressure sections, whichever is less, and shall not exceed 0.0042" per inch of panel span (L/240).
- D. Under 52°F supply air temperature and design conditions on the exterior of the unit of 80°F dry bulb and 71°F wet bulb, condensation shall not form on the casing exterior. The AHU manufacturer shall provide tested casing thermal performance for the scheduled supply air temperature plotted on a psychrometric chart. The design condition on the exterior of the unit shall also be plotted on the chart. If tested casing thermal data is not available, AHU manufacturer shall provide, in writing to the Engineer and Owner, a guarantee against condensation forming on the unit exterior at the stated design conditions above. The guarantee shall note that the AHU manufacturer will cover all expenses associated with modifying units in the field should external condensate form on them. In lieu of AHU manufacturer providing a written guarantee, the installing contractor must provide additional external insulation on AHU to prevent condensation.

1.4 ACTION SUBMITTALS

- A. Product Data: For each air-handling unit indicated.
 - 1. Unit dimensions and weight.
 - 2. Cabinet material, metal thickness, finishes, insulation, and accessories.

3. Fans:
 - a. Certified fan-performance curves with system operating conditions indicated.
 - b. Certified fan-sound power ratings.
 - c. Fan construction and accessories.
 - d. Motor ratings, electrical characteristics, and motor accessories.
4. Certified coil-performance ratings with system operating conditions indicated.
5. Dampers, including housings, linkages, and operators.
6. Filters with performance characteristics.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 1. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 2. Support location, type, and weight.
 3. Field measurements.
- B. Field quality-control reports.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.7 MATERIALS MAINTENANCE SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 1. Filters: One set(s) for each air-handling unit.

1.8 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
- D. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Comply with NFPA 70.

1.9 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate sizes and locations of structural-steel support members, if any, with actual equipment provided.

1.10 WARRANTY

- A. Special Warranty: Provide manufacturer's warranty for the entire unit covering both parts and labor.
 - 1. Warranty period of 5 years from shipment of equipment.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B.
 - 1. McQuay International – Vision.
 - 2. Trane; American Standard Inc – Performance Climate Changer.
 - 3. Carrier Corporation – 39M.

2.2 UNIT CASINGS

- A. General Fabrication Requirements for Casings:
 - 1. Forming: Formed and reinforced double-wall insulated panels, fabricated to allow removal for access to internal parts and components, with joints between sections sealed.
 - a. Outside Casing: Galvanized steel, 0.0635 inch thick.
 - b. Inside Casing: Stainless steel, 0.0276 inch. Entire interior shall be stainless steel.
 - 1) Exception: AHU4-1-1, AHU4-1-2, AHU5-1-1, AHU5-1-2, AHU5-1-3, AHU5-1-4, AHU7-1-1, AHU7-1-2 do not require stainless interiors
 - 2.
- B. Casing Insulation and Adhesive:
 - 1. Materials: Injectable foam insulation with a minimum R-13 value.
 - 2. Location and Application: Encased between outside and inside casing.
- C. Inspection and Access Panels and Access Doors:
 - 1. Panel and Door Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2. Inspection and Access Panels:
 - a. Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 - 3. Access Doors:

- a. Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - b. Gasket: Neoprene, applied around entire perimeters of panel frames.
 - c. Size: At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
 4. Locations and Applications:
 - a. Fan Section: Inspection and access panels Doors.
 - b. Access Section: Doors.
 - c. Coil Section: Inspection and access panel.
 - d. Damper Section: Doors.
 - e. Filter Section: Doors large enough to allow periodic removal and installation of filters.
 - f. Mixing Section: Doors.
- D. Condensate Drain Pans:
1. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - a. Depth: A minimum of 2 inches deep.
 2. Formed sections.
 3. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 4. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
 - a. Minimum Connection Size: NPS 1.
 5. Pan-Top Surface Coating: Asphaltic waterproofing compound.
 6. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- E. Air-Handling-Unit Mounting Frame: 6" height formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.

2.3 FAN, DRIVE, AND MOTOR SECTION

- A. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
1. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
 - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
 - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- B. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
1. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
 2. Horizontal-Flanged, Split Housing: Bolted construction.
 3. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
 4. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches wide attached to 2 strips of 2-3/4-inch-wide, 0.028-inch-thick, galvanized-steel sheet or 0.032-inch-thick aluminum sheets; select metal compatible with casing.

- a. Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
 - 1) Fabric Minimum Weight: 26 oz./sq. yd..
 - 2) Fabric Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3) Fabric Service Temperature: Minus 40 to plus 200 deg F.
- C. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- D. Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
- E. Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.
- F. Fan Shaft Bearings:
 1. Prelubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with ABMA L-10 life at 40,000 hours.
- G. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 service factor based on fan motor.
 1. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
 2. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
 3. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
 4. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch-thick, 3/4-inch diamond-mesh wire screen, welded to steel angle frame; prime coated.
- H. Internal Vibration Isolation: Fans shall be factory mounted with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 2 inch.
- I. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 1. Enclosure Type: Open Drip Proof, fan cooled.
 2. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 3. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 4. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

2.4 COIL SECTION

- A. General Requirements for Coil Section:

1. Comply with ARI 410.
2. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
3. Coils shall not act as structural component of unit.
4. Coil casing shall be stainless steel

2.5 DAMPERS

- A. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm face velocity through damper and 4-inch wg pressure differential.
- B. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation and Control for HVAC."
- C. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel-blade arrangement with cadmium-plated steel operating rods rotating in stainless-steel sleeve, sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 4 cfm/sq. ft. at 1-inch wg and 9 cfm/sq. ft. at 4-inch wg.
- D. Combination Filter and Mixing Section:
 1. Cabinet support members shall hold 2-inch-thick, pleated, flat, permanent or throwaway filters.

2.6 COLD-PLASMA AIR PURIFIERS

- A. The Needlepoint Cold Plasma Generator shall be provided by others and either factory installed or installed by a factory approved representative in the field.
- B. General Requirements for Needlepoint Cold Plasma Generators:
 1. UL and CE listed
 2. Ionizers shall be AC type ionizers with one electrode pulsing between positive and negative.
 3. Bi-Polar Ionization bar construction: 316 medical grade stainless steel.
 4. Shall not contain titanium dioxide (TiO₂).
 5. All electronic components shall be potted and able to withstand environments with relative humidity up to 100%.
 6. Constructed of 100% USA sourced materials and components and assembled in the USA.
- C. Performance:
 1. Pass all requirements of DO-160 testing.
 2. Ozone produced shall not exceed 0.007 PPM as per UL 867 ozone chamber test.
 3. Output shall be at least 35 million ions per cubic inch.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Equipment Mounting: Install air-handling units on concrete bases using elastomeric mounts. Secure units to anchor bolts installed in concrete bases.
 - 1. Install galvanized-steel plate to equally distribute weight over elastomeric pad.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Arrange installation of units to provide minimum 3 feet access space around air-handling units for service and maintenance.
- C. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air-handling unit to allow service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping." Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories."

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
 - 2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.5 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 1. Complete installation and startup checks according to manufacturer's written instructions.
 2. Verify that shipping, blocking, and bracing are removed.
 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 6. Comb coil fins for parallel orientation.
 7. Verify that proper thermal-overload protection is installed for electric coils.
 8. Install new, clean filters.
 9. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling units include the following:
 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions.
 2. Measure and record motor electrical values for voltage and amperage.
 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.6 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.

3.7 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.8 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

END OF SECTION 23 73 13

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SECTION 26 05 00 - COMMON WORK RESULTS FOR ELECTRICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electrical installation requirements.
 - 6. Commissioning requirements.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 GENERAL REQUIREMENTS

- A. Carefully examine General Conditions, other specification sections, and other drawings (in addition to DIVISION 26), in order to be fully acquainted with their effect on electrical work. Additions to the contract cost will not be allowed due to failure to inspect existing conditions.
- B. Do all work in compliance with 6th Edition Florida Building Code 2017, and the Codes adopted therein, including NFPA 70 (2014 NEC), 6th Edition Florida Fire Prevention Code and the regulations of the local power utility, cable television and telephone companies. Obtain and pay for any and all required permits, inspections, certificates of inspections and approval, and the like, and deliver such certificates to the Architect/Engineer.
- C. Cooperate and coordinate with all other trades. Perform work in such manner and at such times as not to delay work of other trades. Complete all work as soon as the condition of the structure and installations of equipment will permit. Patch, in a satisfactory manner and by the proper craft, any work damaged by electrical workmen.
- D. Furnish, perform, or otherwise provide all labor (including, but not limited to, all planning, purchasing, transporting, rigging, hoisting, storing, installing, testing, chasing, channeling, cutting, trenching, excavating and backfilling), coordination, field verification, equipment installation, support, and safety, supplies, and materials necessary for the correct installation of complete and functional electrical systems (as described or implied by these specifications and the applicable drawings).

- E. Coordinate and verify power and telephone company service requirements prior to bid. Bid to include all work required.
- F. Circuiting and connection of all items using electric power shall be included under this division of the specifications, including necessary wire, conduit, circuit protection, disconnects and accessories. Secure rough-in drawings and connection information for equipment involved to determine the exact requirements. See all divisions of drawings or specifications for electrically operated equipment. If the connection of an item is not shown on the electrical drawings and it is unclear how to provide for the circuiting and connection, notify the engineer of record in writing prior to bidding project. Submission of a bid indicates that the bidder has included these requirements as part of the scope of work.

1.5 DRAWINGS:

- A. Indicate only diagrammatically the extent, general character, and approximate location of work. Where work is indicated, but with minor details omitted, furnish and install it complete and so as to perform its intended functions.
- B. DIVISION 26 work called for under any section of the project specifications, shall be considered as included in this work unless specifically excluded by inclusion in some other branch of the work. This shall include roughing-in for connections and equipment as called for or inferred. Check all drawings and specifications for the project and shall be responsible for the installation of all DIVISION 26 work.
- C. Take finish dimensions at the job site in preference to scale dimensions. Do not scale drawings where specific details and dimensions for DIVISION 26 work are not shown on the drawings, take measurements and make layouts as required for the proper installation of the work and coordination with all drawings and coordination with all other work on the project. In case of any discrepancies between the drawings and the specifications that have not been clarified by addendum prior to bidding, it shall be assumed by the signing of the contract that the higher cost (if any difference in costs) is included in the contract price, and perform the work in accordance with the drawings or with the specifications, as determined and approved by the Architect/ Engineer, and no additional costs shall be allowed to the base contract price.
- D. Carefully check the drawings and specifications of all trades and divisions before installing any of his work. He shall in all cases consider the work of all other trades, and shall coordinate his work with them so that the best arrangements of all equipment, piping, conduit, ducts, rough-in, etc., can be obtained.
- E. Review the specific equipment (such as mechanical, plumbing, kitchen, FFE, etc) minimum circuit ampacity and maximum over current protection requirements of equipment provided by others to confirm it is properly coordinated with the devices being purchased. Notify the AE team immediately upon discovery of discrepancies. This shall be done at the submittal stage prior to purchasing over current protection or installation of conduit, wire, disconnects, breakers, etc. No cost will be allowed for changes to coordinate.
- F. Locations designated for outlets, switches, equipment, etc., are approximate and shall be verified by instruction in these specifications and/or notes on the drawings. Where instructions or notes are insufficient to convey the intent of the design, consult the Architect/Engineer prior to installation.
- G. Obtain manufacturer's data on all equipment, the dimensions of which may affect electrical work. Use this data to coordinate proper service characteristics, entry locations, etc., and to ensure minimum clearances are maintained.

1.6 QUALIFICATIONS OF CONTRACTOR:

- A. DIVISION 26 Contractor shall have had experience of at least the same size and scope as this project, on at least two other projects within the last five years in order to be qualified to bid this project.
- B. Contractor performing any part of this scope of work shall be a State Certified (Type E.C. License) electrical contractor
- C. Provide field superintendent who has had a minimum of four (4) years previous successful experience on projects of comparable size and complexity. Superintendent shall be on the site at all times during construction and must have an active Journeyman's Electrical License.

1.7 SITE VISIT/CONDITIONS

- A. Visit the site of this contract and thoroughly familiarize with all existing field conditions and the proposed work as described or implied by the contract documents. During the course of his site visit, verify every aspect of the proposed work and the existing field conditions in the areas of construction which might affect his work. No compensation or reimbursement for additional expenses incurred due to failure or neglect to make a thorough investigation of the contract documents and the existing site conditions will be permitted.
- B. Install all equipment so that all Code required and Manufacturer recommended servicing clearances are maintained. Coordinate the proper arrangement and installation of all equipment within any designated space. If it is determined that a departure from the Contract Documents is necessary, submit to the A/E, for approval, detailed drawings of the proposed changes with written reasons for the changes. No changes shall be implemented without the issuance of the required drawings, clarifications, and/or change orders.
- C. Submission of a proposal will be construed as evidence that such examination has been made and later claims for labor, equipment or materials required because of difficulties encountered will not be recognized.
- D. Existing conditions and utilities indicated are taken from existing construction documents, surveys, and field investigations. Unforeseen conditions probably exist and existing conditions shown on drawings may differ from the actual existing installation with the result being that new work may not be field located exactly as shown on the drawings. Field verify dimensions of all site utilities, conduit routing, boxes, etc., prior to bidding and include any deviations in the contract. Notify A/E if deviations are found.
- E. All existing electrical is not shown. Become familiar with all existing conditions prior to bidding, and include in the bid the removal of all electrical equipment, wire, conduit, devices, fixtures, etc. that is not being reused, back to it's originating point.
- F. Locate all existing utilities and protect them from damage. Pay for repair or replacement of utilities or other property damaged by operations in conjunction with the completion of this work.
- G. Investigate site thoroughly and reroute all conduit and wiring in area of construction in order to maintain continuity of existing circuitry. Existing conduits indicated in Contract Documents indicate approximate locations. Verify and coordinate existing site conduits and pipes prior to any excavation on site. Bids shall include hand digging and all required rerouting in areas of existing conduits or pipes.

- H. Work is in connection with existing buildings which must remain in operation while work is being performed. Work shall be in accord with the schedule required by the Contract. Schedule work for a minimum outage to Owner. Notify Owner 72 hours in advance of any shut-down of existing systems. Perform work during non-school operating hours unless otherwise accepted by Owner. Protect existing buildings and equipment during construction.

1.8 COMMISSIONING RESPONSIBILITIES

- A. Attend commissioning meetings scheduled by the CM.
- B. Schedule work so that required electrical installations are completed, and system verification checks and functional performance test can be carried out on schedule.
- C. Inspect, check and confirm in writing the proper installation and performance of all electrical services as required by the system verification and functional performance testing requirements of electrical equipment in the commissioning specifications.
- D. Provide qualified personnel to assist and operate electrical system during system verification checks and functional performance testing of HVAC systems as required by the commissioning specifications.
- E. Provide instruction and demonstrations for the Owner's designated operating staff in accordance with the requirements of the commissioning specifications.

1.9 TEMPORARY POWER:

- A. Provide temporary power distribution for the connection of all single phase 120V 20A tools, OSHA work lighting, and testing as required for performance of the project. Provide OSHA required work lighting and task lighting for the project.
- B. Coordinate requirements with the local Utility Company for availability of adequate power. Include all cost associated with any Utility Company charges for connection or upgrades in this bid price.
- C. If power to any of the existing facilities will be interrupted, coordinate the outage with the Owner atleast 72 hours in advance. All power outages will occur outside operational hours as determined by the Owner.
- D. Provide temporary power to any buildings, parking lot lighting, canopy lighting, lift stations, etc that will have power removed during the course of construction temporarily. Additionally, if any new buildings, parking lots, lift stations, etc will need power until the permanent power becomes available, provide temporary power until the permanent power is available.
- E. Provide temporary lighting for all areas that will require lighting for school use as well as construction use during the course of construction. Temporary lighting must comply with all FBC requirements as though it was being installed for permanent use. This includes but is not limited to any temporary canopies, parking lots, walkways or roads. If you are unsure of how to connect or provide this lighting, notify the engineer of record in writing prior to bidding project. Submission of a bid indicates that the bidder has included these requirements as part of the scope of work.

PART 2 - PRODUCTS

2.1 NOT USED

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Engineer shall have no responsibility for job site safety and the Contractor shall have full and sole authority for all safety programs and precautions in connection with the Work. Nothing herein shall be interpreted to confer upon the Engineer any duty regarding safety or the prevention of accidents at the jobsite.
- B. Comply with NECA 1.
- C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- D. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- E. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- F. Right of Way: Give to piping systems installed at a required slope.
- G. All work shall be executed in a workmanship manner and shall present a neat mechanical appearance upon completion.
- H. Care shall be exercised that all items are plumb, straight, level.
- I. Care shall be exercised so that Code clearance is allowed for all panels, controls. etc., requiring it. Do not allow other trades to infringe on this clearance.
- J. Balance load as equally as practicable on all feeders, circuits and panel buses.
- K. The electrical circuits, components and controls for all equipment are selected and sized based on the equipment specified. If substitutions are proposed, furnish all materials and data required to prove equivalence. No additional charges shall be allowed if additional materials, labor, connections or equipment are needed for substituted products.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

- C. Coordinate with roofing scope of work for the installation of electrical items which pierce roof. Roof penetrations shall not void warranty. Pitch pockets are not acceptable.
- D. Where work pierces waterproofing, it shall maintain the integrity of the waterproofing. Coordinate roofing materials which pierce roof for compatibility with membrane or other roof types.
- E. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- F. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- G. Cut sleeves to length for mounting flush with both surfaces of walls.
- H. Extend sleeves installed in floors **2 inches** above finished floor level.
- I. Size pipe sleeves to provide **1/4-inch** annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- J. Seal space outside of sleeves with grout for penetrations of concrete and masonry
- K. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
- L. Fire-Rated-Assembly Penetrations: Firestop penetrations of walls, partitions, ceilings, and floors under Division 07 Section "Firestopping."
- M. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work. The use of pitch pockets is not acceptable.

3.3 DEMOLITION

- A. Unless otherwise specified, all equipment and materials shall remain the property of the Owner. Owner shall have first rights to all demolished items if they decide it is usable. This selected property of Owner shall be delivered to a location where directed by Owner within 15 miles of site and all other items shall be removed from the job site and legally disposed of by the Contractor.
- B. Cut no structural members without written approval from the structural engineer of record and Owner.

3.4 MISCELLANEOUS CIRCUITS REQUIRED

- A. Provide 120 volt, 20 amp circuit to building control panels for HVAC system (whether shown on drawings or not). Connect to spare 20 amp, 1 pole circuit breaker in nearest 120 volt panel. Notify Engineer of Record of required circuit so that final circuit information may be added to the drawings. Re-label circuit breaker accordingly. Coordinate location with drawings or specifications prior to bid and provide all electrical.

END OF SECTION 26 05 00

SECTION 26 05 01 - INVESTIGATION OF EXISTING ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including Contractual conditions and Division 1 Specification sections apply to this section.

1.2 SUMMARY

- A. This section includes the requirements for investigation and reporting on conditions of existing electrical systems.

1.3 DESCRIPTION

- A. Test the essential features of existing electrical power, lighting and systems.
- B. Each system shall be tested once only, and after completion of testing, results given to the Owner. Point out any non-operational function noticed during testing.
- C. Document the existing conditions and operation of the existing electrical systems prior to any work.
- D. Contractor shall be responsible for all non-working systems and their components unless non-working status is verified prior to work on system.

1.4 COORDINATION

- A. The testing shall be held at a date to be agreed upon in writing by the Owner.

PART 2 - PRODUCTS (not applicable)

PART 3 - EXECUTION

3.1 PERFORMANCE VERIFICATION

- A. The contractor shall investigate all existing systems prior to the beginning any work on site. Test the functionality of each system and report only those items that are non-functional to the Owner.
- B. Demonstrate to the Owner the non-functional items to verify the issue. Owner will at its option correct the deficiency immediately or defer to correct until the construction is completed. Provide a written report to clarify the items and the Owners decisions on correction,

- C. Each system shall be retested after completion of renovation to ensure proper operation.
- D. At the completion of construction, the Owner will expect all power, lighting and systems to function for their intended purpose whether new or existing. The contractor will remain responsible for this unless noted otherwise during the initial investigation and documented and demonstrated as such.

3.2 MEMO OF INVESTIGATION (TESTING)

- A. Submit Existing Facilities Investigation Memo and advise Owner of all deficiencies in system(s) prior to Work. All systems will be assumed to be fully operational if Memo is not received by Owner prior to work on system.

END OF SECTION 26 05 01

SECTION 26 05 19 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.
 - 4. Metal Clad cable, Type MC
- B. Related Sections include the following:
 - 1. Division 27 Section "Data Communications Integration" for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Provide type and UL listing of each type of conductor, cable, connector and termination to be utilized for the DIVISION 26 scope of work.
- B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

- A. Listing and Labeling: Provide wires and cables specified in this Section that are listed and labeled as defined in NFPA 70, Article 100.
- B. Comply with NFPA 70.

1.6 COORDINATION

- A. Coordinate layout and installation of cables with other installations.

- B. Revise locations and elevations from those indicated, as required to suit field conditions and as approved by Architect.

PART 2 - PRODUCTS

2.1 CONDUCTORS AND CABLES

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

1. Alcan Products Corporation; Alcan Cable Division.
2. American Insulated Wire Corp.; a Leviton Company.
3. General Cable Corporation.
4. Senator Wire & Cable Company.
5. Southwire Company.

- B. BUILDING WIRES AND CABLES

1. CONDUCTOR INSULATION

- a. Comply with NEMA WC 70 for Types THHN-THWN
- b. Service Entrance: Type THHN-THWN CU or XHHW-2 Al, single conductors in raceway.
- c. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- d. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway.
- e. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway.
- f. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- g. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway or Metal-clad cable, Type MC (MC may only be utilized in certain specific installations as described elsewhere in this section).
- h. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway. Minimum #12.
- i. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway. Minimum #12.
- j. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- k. Class 1 Control Circuits: Type THHN-THWN, in raceway.
- l. Class 2 Control Circuits: Type THHN-THWN, in raceway.

2. CONDUCTOR MATERIAL:

- a. Copper Conductors: Comply with NEMA WC 70.
- b. All #10 and smaller conductors shall be solid CU. No stranded conductors are permitted for #10 and smaller.
- c. Aluminum conductors may be used for 1/0 and larger panel board feeders if identified as aluminum on the electrical feeder schedule. Aluminum conductors shall be compact stranded aluminum alloy with XHHW-2 insulation, made of an AA-8000 series electrical grade aluminum alloy conductor material.

2.2 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
 2. AMP Incorporated
 3. Anderson
 4. O-Z/Gedney; EGS Electrical Group LLC.
 5. 3M; Electrical Products Division.
 6. Burndy
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.
- C. Aluminum connections shall be made with compression type wire barrels factory prefilled with oxide inhibiting compound. Set screw connectors are not acceptable.

2.3 FLEXIBLE METAL CLAD CABLE

- A. Comply with:
1. NFPA 70
 2. ANSI/UL 4/UL 83/UL 1479
 3. Fed. Specification J-C-30B
- B. Cable material:
1. Jacket material:
 - a. Galvanized Steel or aluminum , interlocked.
 2. Conductor covering: Paper wrap.
 3. Conductor Material:
 - a. Copper, Solid, THHN
 - b. Minimum #12 gauge
 - c. Maximum #10 gauge
 - d. 90 degree C, 600 volt.
 - e. Full size insulated grounding conductor, green.
 - f. Conductor color coding to match system voltage. Comply with Division 26 Section "Identification".
- C. Fittings:
1. ANSI/NEMA FB 1
 2. ANSI/UL 514B
 3. Zinc plated Malleable iron, or steel.
 - a. Direct flexible conduit bearing set screw type not acceptable.
 - b. Install insulated bushings or equivalent protection (i.e. Anti-short) between core conductors and outer jacket.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUCTORS AND CABLES IN RACEWAY

- A. No cables shall be installed in raceways until the raceway system is complete from end to end.
- B. Examine raceways and building finishes to confirm compliance with contract requirements for installation tolerances and other conditions affecting installation of wires and cables. Do not proceed with installation until area is ready and any unsatisfactory conditions have been corrected.
- C. Verify that interior of building has been protected from weather.
- D. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- E. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."
- G. All branch circuit wire shall be sized for a maximum voltage drop of 3%. The contractor shall size all cables to comply with this requirement. Below are some guidelines that may be followed to achieve the correct voltage drop in lieu of providing custom calculations for each case.
 - 1. Use conductor not smaller than #12 AWG for all 120V 20A branch circuits less than 60' in length from the source breaker to any device.
 - 2. All 120V branch circuit conductors where the length is 61' to 120' from the source breaker to any device shall utilize #10 minimum throughout the circuit, unless otherwise noted.
 - 3. All 120V branch circuit conductors where the length is 121' to 240' from the source breaker to any device shall utilize # 8 minimum throughout the circuit, unless otherwise noted.
 - 4. All 120V branch circuit conductors where the length is greater than 241' from the source breaker to any device shall utilize # 6 minimum throughout the circuit, unless otherwise noted.
 - 5. Use conductor not smaller than #12 AWG for all 277V 20A branch circuits less than 140' in length from the source breaker to any device.
 - 6. All 277V branch circuit conductors where the length is 141' to 220' from the source breaker to any device shall utilize #10 minimum throughout the circuit, unless otherwise noted.
 - 7. All 277V branch circuit conductors where the length is 221' to 340' from the source breaker to any device shall utilize # 8 minimum throughout the circuit, unless otherwise noted.
 - 8. All 277V 20A branch circuit conductors where the length is greater than 341' from the source breaker to any device shall utilize # 6 minimum throughout the circuit, unless otherwise noted.
- H. Provide a dedicated neutral conductor for all dimmer circuits from the load back to the dimmer module or switch.
- I. Provide a dedicated neutral conductor for all computer receptacle circuits from the load back to the branch circuit panel board.

- J. Neatly train and lace wiring inside boxes, equipment, and panelboards.
- K. Conductor sizes indicated on circuit homeruns or in schedules shall be installed over the entire length of the circuit unless noted otherwise on the drawings or in these specifications.
- L. Before installing raceways and pulling wire to any mechanical equipment, verify electrical characteristics with final submittal on equipment to assure proper number and AWG of conductors. (As for multiple speed motors, different motor starter arrangements, etc.).
- M. Coordinate all wire sizes with lug sizes on equipment, devices, etc. Provide/install lugs as required to match wire size.

3.2 INSTALLATION REQUIREMENTS FOR METAL CLAD CABLES

- A. Metal Clad Cables may be used only as specified, where permitted by NEC, and if approved by the Local Inspecting Authority having Jurisdiction.
- B. MC Cable shall not be run to the panel board or electrical room. All final runs to the panelboard shall be in conduit to a point at least 10' outside the electrical room. No more than 6 current carrying conductors shall be run in any conduit to a junction box outside the electrical room. No junction box shall contain more than 6 current carrying conductors. Wireways are not permitted for the termination of MC cables.
- C. MC cable shall not be used for any other building system wiring (except power and lighting).
- D. MC cables shall not be used for switch legs.
- E. MC cables shall not be used for feeder circuits or for systems.
- F. Utilize the same sizing requirements for 20A branch circuit conductors as listed for conductors in raceways.
- G. Connectors and supporting components shall be UL Listed for such use. Tie wire is not acceptable for supporting MC cable.
- H. Cut cables with UL listed tools intended for such use. Ream smooth and free of sharp and abrasive areas. Install bushing between conductors and outer jacket. The use of slide cutters or dikes to cut cables is not acceptable.
- I. Maintain minimum 1/2 inch separation between each cable and support per NEC. The practice of bundling cables is not acceptable.
- J. Install cables minimum of 1'-0" from communications cables.
- K. Attachment of cables to ceiling system is prohibited.
- L. Attachment of cables to, on, or from mechanical (HVAC) equipment, supports, etc., is not permitted.
- M. Install cables parallel and perpendicular to building structure.
- N. Zigzagging cables through building elements, as method of support is not acceptable.

- O. Cable with outer metal sheath damaged by construction elements and/or improper installation shall be replaced at no additional cost to owner.

3.3 CONNECTIONS

- A. Where oversized conductors are called for (due to voltage drop, etc.) provide/install lugs as required to match conductors, or provide/install splice box, and splice to reduce conductor size to match lug size.
- B. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- C. All aluminum connections shall be made with approved compression connectors before being connected to lugs. Conductors shall be cleaned with a wire brush immediately prior to connecting.
- D. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- E. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.
- F. Power and lighting conductors shall be continuous and unspliced where located within conduit. Splices shall occur within troughs, wireways, outlet boxes, or equipment enclosures where sufficient additional room is provided for all splices. No splices shall be made in in-ground pull boxes (without written acceptance of engineer).
- G. Splices in lighting and power outlet boxes, wireway, and troughs shall be kept to a minimum, pull conductors through to equipment, terminal cabinets, and devices.
- H. No splices shall be made in junction box, and outlet boxes (wire No. 8 and larger) without written acceptance of Engineer.
- I. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B. A calibrated torque wrench shall be used for all bolt tightening.
- J. All interior power and lighting taps and splices in No. 8 or smaller shall be fastened together by means of "spring type" connectors. All taps and splices in wire larger than No. 8 shall be made with compression type connectors and taped to provide insulation equal to wire. Utilize weatherproof connectors for all splices in exterior boxes.
- K. No splices are permitted in exterior below grade handhole or pull boxes.

3.4 FIELD QUALITY CONTROL

- A. After feeders are in place, but before being connected to devices and equipment, test for shorts, opens, and for intentional and unintentional grounds.
- B. Cables 600 volts or less in size #1/0 and larger shall be meggered using an industry approved "megger" with 1000 V internal generating voltage. Readings shall be recorded and submitted to the Engineer for acceptance prior to energizing same. If values are less than recommended NETA values notify Engineer. Submit five copies of tabulated megger test values for all cables.

- C. Cables 250 volts or less in size #1/0 and larger shall be meggered using an industry approved "megger" with 500 V internal generating voltage. Readings shall be recorded and submitted to the Engineer, for acceptance prior to energizing same. Submit five copies of tabulated megger test values for all cables.
- D. Perform Insulation resistance test and turns ratio test. Submit five copies to engineer at substantial completion.
- E. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 19

SECTION 26 05 26 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes methods and materials for grounding systems, equipment and common ground bonding with lightning protection system.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Field quality-control test reports.

1.4 QUALITY ASSURANCE

- A. Comply with UL 467 for grounding and bonding materials and equipment.
- B. Test all ground rod locations as described to confirm quality standard intent is attained.

PART 2 - PRODUCTS

2.1 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Tinned Conductors: ASTM B 33.
 - 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 - 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- C. Grounding Bus: Rectangular bars of annealed copper, 1/4 by 4 inches in cross section, unless otherwise indicated; with insulators.

2.2 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- D. Lugs: Compression of substantial construction, cast copper or cast bronze, with "ground" (micro-flat) surfaces, compression type, two-hole tongue, equal to Burndy or equal by T&B or OZ Gedney. Lightweight and "competitive" devices shall be rejected.
- E. Grounding and Bonding Bushings: Malleable iron, Thomas and Betts (T&B), or equal.
- F. Grounding Screw and Pigtail: Raco No. 983 or equal.
- G. Building Structural Steel, Existing: Thompson 701 Series heavy duty bronze "C" clamp with two-bolt vise-grip cable clamp or equal.

2.3 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel, sectional type; 5/8 inch by 10 feet in diameter.

2.4 GROUNDING WELL COMPONENTS

- A. All Areas:
 - 1. Well: Minimum 12 inch long by 12 inch wide by 18 inches deep with open bottom.
 - 2. Well Cover: Traffic rated for use with "GROUND" embossed on cover.
 - 3. Material: Composolite.
 - 4. Manufacturer: Quazite.
 - 5. Increase depth, diameter or size as required to provide proper access at installed location.

2.5 GROUNDING BARS/GROUND BUS (INCLUDING 'SYSTEMS' GROUND BUS/BARS AND GROUND BUS BARS)

- A. Ground bars shall be copper of the size and description as shown on the drawings. If not sized on drawings, bus bar shall be minimum 1/4" x 4" bus grade copper, spaced from wall on insulating 2" polyester molded insulator standoff/supports, and be 12" or greater minimum overall length, allowing 2" length per lug connected thereto. Increase overall length as required to facilitate all lugs required while maintaining 2" spacing. Size of bus bar used in main electrical room shall be similar except minimum of 4" high and 24" long.
- B. Provide bolt-tapping lug with two hex head mounting bolts for each terminating ground conductor, sized to match conductors. Mount on bus bar at 2 inches on center spacing. Lugs to be manufactured by Burndy or T&B.

- C. Standoff supports to be 2" polyester as manufactured by Glastic #2015-4C.

PART 3 - EXECUTION

3.1 GROUNDING ELECTRODES

- A. All connections shall be exothermic welded unless otherwise noted herein. All connections above grade and in accessible locations may be by exothermic welding or by braising or clamping with devices UL listed as suitable for use except in locations where exothermic welding is specifically specified in these specifications or called for on drawings.
- B. Each rod shall be die stamped with identification of manufacturer and rod length.
- C. Install rod electrodes at locations indicated and/or as called for in these specifications.
- D. Ground Resistance:
 - 1. Main Electrical Service (to each building):
 - a. Grounding resistance measured at each main service electrode system.
 - 2. Other Locations:
 - a. Resistance to ground of all non-current carrying metal parts shall not exceed 5 ohms measured at motors, panels, busses, cabinets, equipment racks, light poles, transformers, and other equipment.
 - 3. Lightning Protection system ground locations shall not exceed 5 ohms for the Franklin system measured at ground electrode.
 - 4. Resistance called for above shall be maximum resistance of each ground electrode prior to connection to grounding electrode conductor. Where ground electrode system being measured consists of two (2) or more ground rod electrodes then the resistance specified above shall be the maximum resistance with two (2) or more rods connected together but not connected to the grounding electrode conductor.
- E. Install additional rod electrodes as required to achieve specified resistance to ground (specified ground resistance is for each ground rod location prior to connection to ground electrode conductor). Depending on soil condition, etc. of ground rod locations it has been found that the ground rod lengths required to achieve the specified resistance may range from the minimum specified length to up to 80 feet or more in length.
- F. Verify that final backfill and compaction has been completed before driving rod electrodes.
- G. Install ground rods not less than 1 foot below grade level and not less than 2 feet from structure foundation.

3.2 EQUIPMENT GROUNDING CONDUCTOR

- A. Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
- B. Provide green insulated ground wire for all grounding type receptacles and for equipment of all voltages. In addition to grounding strap connection to metallic outlet boxes, a supplemental

grounding wire and screw equal to Raco No. 983 shall be provided to connect receptacle ground terminal to the box.

- C. All plugstrips and metallic surface raceway shall contain a green insulation ground conductor from supply panel ground bus connected to grounding screw on each receptacle in strip and to strip channel. Conductor shall be continuous.
- D. All motors, all heating coil assemblies, and all building equipment requiring flexible connections shall have a green grounding conductor properly connected to the frames and extending continuously inside conduit with circuit conductors to the supply source bus with accepted connectors regardless of conduit size or type. This shall include Food Service equipment, Laundry equipment, and all other "Equipment By Owner" to which an electric conduit is provided under this Division.

3.3 MAIN ELECTRICAL SERVICE

- A. Existing Buildings:
 - 1. Verify that each building's electrical service is properly grounded as required by the NEC.
 - 2. Provide and install electrical service grounding at each building as called for herein for all existing services that do not comply with the grounding specified above.
 - 3. Supplement existing electrical service grounding at each building as required to comply with all requirements in these specifications.
 - 4. If exterior ground rod electrode does not exist at each buildings main electrical service, provide and install these ground rods as called for main electrical service, exterior of building. Connect all counterpoise conductors required elsewhere thereto.
- B. Ground electrodes shall be provided for the main service in sufficient number and configuration to secure resistance specified.
- C. Bond to all of the following when available on site:
 - 1. Ground Rods
 - 2. Metal Water Pipe (Interior and Exterior to Building)
 - 3. Building Metal Frame, Structural Steel and/or Reinforced Structural Concrete
 - 4. All Piping Entering or Leaving All Buildings (Including Chilled Water Piping)
 - 5. Encasing Electrodes
 - 6. Site Distribution Counterpoise Ground System
 - 7. Lightning Protection System
- D. A main ground, bare copper conductor, sized per applicable table in NEC, but in no case less than #2/0, shall be run in conduit from the main switchgear of each building to the building steel in respective building. This ground conductor shall also be run individually from the main switchgear and be bonded to the main water service ahead of any union in pipe and must be metal pipe of length as acceptable by authorities having jurisdiction. Provide properly sized bonding shunt around water meter and/or dielectric unions in the water pipe. Also required is the same size ground wire to ground rod electrode as called for below:
 - 1. Three 30 ft. ground rods in a delta configuration at no less than 30 ft. spacing driven to a minimum depth of 30 ft. plus 1 below grade.
 - 2. Bond ground rod electrodes together with a bare copper ground conductor that matches size required by applicable table in NEC 250, but in no case less than #2/0.
 - 3. Provide additional rod electrodes as required to achieve specified ground resistance.
- E. Ground/bond neutral per NEC.

- F. Bond grounding electrodes to site counterpoise grounding system and lightning protection system where provided.
- G. Provide and install ground bus bar on wall near main service disconnect/switchboard. Connect to ground bar in disconnect/switchboard bonded to switchboard/disconnect enclosure/neutral with copper grounding conductor sized per applicable table in NEC.

3.4 TRANSFORMER GROUNDING

- A. Ground all transformers and enclosures of 120/208V and 277/480V "separately derived systems" as specified herein.
 - 1. Ground per NEC 250 and these specifications.
 - 2. Bond neutral to transformer frame/enclosure and the equipment grounding conductors of the derived system with copper ground conductor sized per applicable table in NEC.
 - 3. Connect transformer neutral/ground to grounding electrode per NEC with grounding electrode conductor sized per applicable table in NEC.
 - 4. In addition to connection to grounding electrode conductor called for above (i.e. per NEC) provide, install and connect supplemental grounding electrode as follows:
 - a. Where grounding required per NEC is to building steel/structure, supplement this grounding with connection to nearest available effectively grounded metal water pipe.
 - b. Where grounding connection required per NEC is to grounded metal water pipe, supplement this grounding with connection to other electrodes specified in NEC.
 - c. Where supplemental grounding electrodes required above is a ground rod electrode, provide, install and connect two or more 30 ft. ground rod electrodes at no less than 30 ft. spacing, driven vertical to a minimum depth of 30 ft. plus 1 below grade.
 - 5. Where neither building steel nor water pipe grounding electrodes are available (i.e. exterior locations with no available water pipe electrode) provide two (2) ground connections: each to two (2) or more 30 ft. ground rod electrodes at no less than 30 ft. spacing, driven vertical to a minimum depth of 30 ft. plus 1 below grade.
 - 6. Where transformer is mounted exterior to building one (1) of the two (2) ground electrodes required shall be ground rod electrode as called for in 5. above. This ground rod electrode shall also be connected to counterpoise system (wherever counterpoise system is available).
 - 7. Ground to water system service pipe as required by NEC.
- B. Provide additional ground electrodes as required to achieve specified ground resistance.
- C. Where two or more ground electrodes are used at any one required ground location, they shall be bonded together with a copper ground conductor, sized to meet applicable table in NEC, but in no case less than #2/0.
- D. Provide and install ground bus bar on wall near transformer (or in associated electrical room for exterior mounted transformers). Connect to ground lug in transformer bonded to transformer enclosure/neutral with copper ground conductor sized per applicable table in NEC.

3.5 LIGHTNING PROTECTION SYSTEMS

- A. Ground per applicable section on lightning protection system, NFPA 780, and as specified herein. The most stringent requirements shall govern.

- B. Bond lightning protection system grounds to electrical service system ground, all piping entering or leaving all buildings, and counterpoise system ground where provided.
- C. Lightning protection ground rods shall be 20' in length and should not be driven deeper. If additional rods are required to achieve the required resistance to ground, they should be added in parallel with the first at one rod length separation.

3.6 EXTERIOR GRADE (OR FREE STANDING ABOVE GROUND) MOUNTED EQUIPMENT

- A. General:
 - 1. All equipment (including chillers, pumps, disconnects, starters, control panels, panels, etc) mounted exterior to building shall have their enclosures grounded directly to a grounding electrode at the equipment location in addition to the building equipment ground connection.
 - 2. Bond each equipment enclosure, metal rack support, mounting channels, etc. to ground electrode system at each rack with an insulated copper ground conductor sized to match the grounding electrode conductor required by applicable table in NEC based on equipment feeder size, but in no case shall conductor be smaller than #6 copper or larger than #2 copper. This connection is in addition to grounding electrode connections required for services.
- B. Main electrical service rack mounted equipment.
 - 1. Ground per "MAIN ELECTRICAL SERVICE".
 - 2. Bond all metal parts as noted above.
- C. Electrical sub service rack mounted equipment.
 - 1. Ground per "MAIN ELECTRICAL SERVICE", except do not bond neutral to ground.
 - 2. Bond all metal parts as noted above.
- D. Electrical equipment connection rack mounted equipment.
 - 1. Bond all metal parts as noted above.
- E. Grounding electrodes (ground electrodes system) shall be:
 - 1. Located at each rack location.
 - 2. For service equipment: Ground electrode required per "MAIN ELECTRICAL SERVICE".
 - 3. For equipment connection equipment: Two or more 30 ft. ground rods at no less than 30 ft. spacing, driven vertical to a minimum depth of 1 ft below grade. Bond the two or more ground rods together with a size to meet applicable table in NEC , but no less than a #2 copper ground conductor. Provide additional rod electrodes as required to achieve specified ground resistance.

3.7 MISCELLANEOUS GROUNDING CONNECTIONS

- A. Provide bonding to meet regulatory requirements.
- B. Required connections to building steel shall be with UL accepted non-reversible crimp type ground lugs exothermically welded to bus bar that is either exothermically welded to steel or bolted to steel in locations where weld will not affect the structural properties of the steel.

Required connections to existing building structural steel purlins/l beams shall be with heavy duty bronze "C" clamp with two bolt vise-grip cable clamp.

- C. Grounding conductors shall: be so installed as to permit shortest and most direct path from equipment to ground; be installed in conduit; be bonded to conduit at both ends when conduit is metal; have connections accessible for inspection; and made with accepted solderless connectors brazed (or bolted) to the equipment or to be grounded; in NO case be a current carrying conductor; have a green jacket unless it is bare copper; be run in conduit with power and branch circuit conductors. The main grounding electrode conductor shall be exothermically welded to ground rods, water pipe, and building steel.
 - D. All surfaces to which grounding connections are made shall be thoroughly cleaned to maximum conductive condition immediately before connections are made thereto. Metal rustproofing shall be removed at grounding contact surfaces, for 0 ohms by digital Vm. Exposed bare metal at the termination point shall be painted.
 - E. All ground connections that are buried or in otherwise inaccessible locations, shall be welded exothermically. The weld shall provide a connection which shall not corrode or loosen and which shall be equal or larger in size than the conductors joined together. The connection shall have the same current carrying capacity as the largest conductor.
 - F. Install ground bushings on all metal conduits entering enclosures where the continuity of grounding is broken between the conduit and enclosure (i.e. metal conduit stub-up into a motor control center enclosure or at ground bus bar). Provide an appropriately sized bond jumper from the ground bushing to the respective equipment ground bus or ground bus bar.
 - G. Install ground bushings on all metal conduits where the continuity of grounding is broken between the conduit and the electrical distribution system (i.e. metal conduit stub-up from wall outlet box to ceiling space. Provide an appropriately sized bond jumper from the ground bushing to the respective equipment ground bus or ground bus bar.
 - H. Each feeder metallic conduit shall be bonded at all discontinuities, including at switchboards and all subdistribution and branch circuit panels with conductors in accordance with applicable table in NEC 250 for parallel return with respective interior grounding conductor.
 - I. Grounding provisions shall include double locknuts on all heavywall conduits.
 - J. Bond all metal parts of pole light fixtures to ground rod at base.
 - K. Install grounding bus in all existing panelboards of remodeled areas, for connection of new grounding conductors, connected to an accepted ground point.
 - L. Bond together reinforcing steel and metal accessories in pool and fountain structures.
 - M. Where reinforced concrete is utilized for building grounding system, proper reinforced bonding shall be provided to secure low resistance to earth with "thermite" type devices, and #10AWG wire ties shall be provided to not less than ten (10) full length rebars which contact the connected rebar .
- 3.8 GROUNDING BAR/GROUND BUS (INCLUDING 'SYSTEMS' GROUND BUS/BAR ON GROUND BUS/BAR) INSTALLATION
- A. Where indicated on the drawings, provide and install grounding bar/ground bus (bus bar). These bus installations are intended to provide a low-impedance "earthing" path for surge voltages, which are electrically "clamped" and shunted to earth by variable-impedance surge

protective devices. Metal sheaths of underground cables are also to be grounded thereto at points of building entrance.

- B. Mount bolt tapping lugs with hex head bolts to bus bar at 2" o.c. spacing, one for each ground conductor.
- C. Mount bus bar to wall using 2" polyester molded insulator stand-off.
- D. Extend a #2/0 (minimum size) or larger THWN insulated copper ground conductor (if larger size is called for on drawings or required by N.E.C. for service ground, etc.) in PVC conduit to accepted service ground installation or ground bus/bar in main service equipment enclosure.
- E. Extend #6 insulated copper ground wire from respective bus/bar to each 'local' ground bus/bar in each cabinet for Section 27 systems.
- F. 'SYSTEMS' grounding bus/bar must be connected with #2/0 insulated copper conductor to grounding electrodes system as defined in NEC "Article 800.

3.9 TESTING AND REPORTS

- A. Ground resistance measurements shall be made on each system utilized in the project. The ground resistance measurements shall include building structural steel, driven grounding system, water pipe grounding system and other accepted systems as may be applicable. Ground resistance measurements shall be made in normally dry weather, not less than 24 hours after rainfall, and with the ground under test isolated from other grounds and equipment. Resistances measured shall not exceed specified limits.
- B. Upon completion of testing, the testing conditions and results shall be certified and submitted to the Architect/Engineer.

END OF SECTION 26 05 26

SECTION 26 05 29 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.
- D. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and shown.

1.5 SUBMITTALS

- A. Product Data: For the following:
 - 1. Unistrut
 - 2. Straps
 - 3. Clamps
 - 4. Rods
 - 5. Hangers

6. Anchors
7. Attachment Devices

- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
1. Trapeze hangers. Include Product Data for components.
 2. Steel slotted channel systems. Include Product Data for components.
 3. Nonmetallic slotted channel systems. Include Product Data for components.
 4. Equipment supports.

1.6 QUALITY ASSURANCE

- A. Comply with NFPA 70.

1.7 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-Line, Inc.; a division of Cooper Industries.
 - b. ERICO International Corporation.
 - c. Thomas & Betts Corporation.
 - d. Unistrut; Tyco International, Ltd.
 - e. Wesanco, Inc.
 2. Metallic Coatings: Exterior of the building utilize stainless steel or hot-dip galvanized after fabrication and applied according to MFMA-4. Interior utilize electro-galvanized steel products.
 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 4. Channel Dimensions: Selected for applicable load criteria.
- B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch diameter holes at a maximum of 8 inches o.c., in at least 1 surface.

1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Cooper B-Line, Inc.; a division of Cooper Industries.
 - b. Fabco Plastics Wholesale Limited.
 - c. T & B/Carlton
 - d. Seasafe, Inc.
 2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 3. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
 4. Rated Strength: Selected to suit applicable load criteria.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.

- 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
- 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25percent in future without exceeding specified design load limits.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).
- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts, beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or spring-tension clamps.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- F. Do not support conduit or raceway with wire, metal banding material, or perforated pipe straps. Remove wire used for temporary supports
- G. Do not attach conduit or raceway to ceiling support wires.
- H. Conduits or raceways shall not be supported from ceiling grid supports, plumbing pipes, duct systems, heating or air conditioning pipes, or other building systems.
- I. Non-bolted conduit clamps, spring type conduit clamps, and tie wire are not acceptable for supports. All conduits must be supported with bolted hangers listed for the specific installed application.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

END OF SECTION 26 05 29

SECTION 26 05 33 - RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.
- B. Related Sections include the following:
 - 1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. FMC: Flexible metal conduit.
- E. LFMC: Liquidtight flexible metal conduit.
- F. LFNC: Liquidtight flexible nonmetallic conduit.
- G. NBR: Acrylonitrile-butadiene rubber.
- H. RNC: Rigid nonmetallic conduit.

1.4 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Custom enclosures and cabinets.
 - 2. For handholes and boxes for underground wiring, including the following:

- a. Duct entry provisions, including locations and duct sizes.
 - b. Frame and cover design.
 - c. Grounding details.
 - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
 - e. Joint details.
- C. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
1. Structural members in the paths of conduit groups with common supports.
 2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

1.5 REFERENCES

- A. ANSI C80.1 - Rigid Steel Conduit - Zinc Coated
- B. ANSI C80.3 - Electrical Metallic Tubing - Zinc Coated
- C. ANSI C80.5 - Aluminum Rigid Conduit (ARC)
- D. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
- E. ANSI/NEMA OS 1 - Sheet-steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- G. ANSI/NFPA 70 - National Electrical Code
- H. NECA Standard Practices for Good Workmanship in Electrical Contracting
- I. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.
- J. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit (EPC 40, EPC 80)
- K. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Minimum Trade Size

1. All Conduit (except switch legs) - 3/4"c.
2. Switch legs - 1/2"c.

B. RIGID METALLIC CONDUIT

1. Comply with:

- a. ANSI C80.1
- b. UL Spec - No. 6
- c. NEC 344

2. Conduit material:

- a. Zinc coated or hot dipped galvanized steel.

3. Fittings:

- a. Threaded.
- b. Insulated bushings shall be used on all rigid steel conduits terminating in panels, boxes, wire gutters, or cabinets, and shall be impact resistant plastic molded in an irregular shape at the top to provide smooth insulating surface at top and inner edge. Material in these bushings must not melt or support flame.
- c. Zinc plated or hot dipped galvanized malleable iron or steel.

4. Conduit Bodies:

- a. Comply with ANSI/NEMA FB 1.
- b. Threaded hubs.
- c. Zinc plated or hot-dipped galvanized malleable iron.

C. RIGID ALUMINUM CONDUIT

1. Comply with:

- a. ANSI C80.5
- b. UL 6
- c. NEC 344

2. Conduit material: Aluminum.

3. Fittings:

- a. Threaded.
- b. Aluminum.
- c. Insulated bushings on terminations.

4. Conduit bodies:

- a. Comply with ANSI/NEMA FB 1.
 - b. Threaded hubs.
 - c. Aluminum.
- D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
- 1. Comply with:
 - a. UL 6
 - b. ANSI C80.1
 - c. NEC. 344
 - d. NEMA RN1
 - 2. Conduit material: Hot-dipped galvanized rigid steel with external PVC coating, 20 mil. thick.
 - 3. Fittings:
 - a. Threaded.
 - b. Insulated bushings on terminations.
 - c. Zinc plated or hot-dipped galvanized malleable iron or steel with external PVC coating, 20 mil. thick.
 - 4. Conduit bodies:
 - a. Comply with:
 - b. ANSI/NEMA FB 1
 - c. Threaded hubs
 - d. Zinc plated or hot-dipped galvanized malleable iron with external PVC coating 20 mil thick.
- E. EMT: ANSI C80.3.
- 1. Comply with:
 - a. UL 797
 - b. ANSI C80.3
 - c. NEC 358
 - d. ANSI/UL797
 - 2. Conduit material: Galvanized steel tubing.
 - 3. Fittings:
 - a. ANSI/NEMA FB 1
 - b. Set screw, Die Cast for Interior Dry locations
 - c. Compression, Steel for all damp locations
- F. FMC: Zinc-coated steel or aluminum.
- 1. Comply with:
 - a. NEC 348
 - b. ANSI/UL 1
 - 2. Conduit material: Steel or aluminum, interlocked.

3. Fittings:
 - a. ANSI/NEMA FB 1
 - b. ANSI/UL 514B
 - c. Die Cast
 - d. Threaded rigid conduit to flexible conduit coupling.
 - e. Direct flexible conduit bearing set screw type not acceptable.

G. LFMC: Flexible steel conduit with PVC jacket.

1. Comply with:
 - a. NEC 350
 - b. ANSI/UL 360
2. Conduit material:
 - a. Flexible hot-dipped galvanized steel core, interlocked.
 - b. Continuous copper ground built into core up to 1-1/4" size.
 - c. Extruded polyvinyl gray jacket.
3. Fittings:
 - a. Threaded for rigid conduit connections.
 - b. Accepted for hazardous locations where so installed.
 - c. Provide sealing washer in wet/damp locations.
 - d. Compression type.
 - e. ANSI/NEMA FB 1.
 - f. ANSI/UL 5148.
 - g. Zinc plated malleable iron or steel.

2.2 NONMETALLIC CONDUIT AND TUBING

- A. Minimum Trade Size – 3/4"
- B. RNC: NEMA TC 2, Schedule-40-PVC, unless otherwise indicated.

1. Comply with:
 - a. NEMA TC-2
 - b. UL 651
 - c. NEC 352
2. Conduit material:
 - a. Shall be high impact PVC - tensile strength 55 PSI, flexural strength 11000 PSI.
3. Fittings:
 - a. Comply with: NEMA TC-3 and UL 514.

2.3 EXPANSION FITTINGS

- A. Expansion fittings shall be:
1. UL Listed, hot dipped galvanized inside and outside providing a 4" expansion chamber - when used with rigid conduit and electrical metallic conduit, or:
 2. Be polyvinyl chloride and shall meet the requirements of and as specified elsewhere for non-metallic conduit and shall provide a 6" expansion chamber.
 3. Hot dipped galvanized expansion fitting shall be provided with an external braided grounding and bonding jumper with accepted clamps, UL Listed for the application.
 4. Expansion fitting, UL Listed for the application and in compliance with the National Electrical Code without the necessity of an external bonding jumper may be considered. Submit fitting with manufacturer's data and UL Listing for acceptance prior to installation.

2.4 METAL WIREWAYS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.5 SURFACE RACEWAYS

- A. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected by Architect.
1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Thomas & Betts Corporation.
 - b. Walker Systems, Inc.; Wiremold Company (The).
 - c. Wiremold Company (The); Electrical Sales Division.
 - d. Mono-Systems, Inc.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. RACO; a Hubbell Company.
 8. Robroy Industries, Inc.; Enclosure Division.
 9. Scott Fetzer Co.; Adalet Division.
 10. Spring City Electrical Manufacturing Company.
 11. Thomas & Betts Corporation.
 12. Walker Systems, Inc.; Wiremold Company (The).
 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include 1/2 inch (13 mm) male fixture studs where required.
 2. Concrete Ceiling Boxes: Concrete type.
 3. Interior flush outlet boxes shall be one piece drawn galvanized steel constructed with stamped knockouts in back and sides, and threaded holes with screws for securing box coverplates or wiring devices.
 4. Ceiling outlet boxes shall be 4" octagonal or 4" square X 1 1/2" deep or larger as required for number and size of conductors and arrangement, size and number of conduits terminating at them.
 5. Switch, wall receptacle, telephone and other recessed wall outlet boxes in drywall shall be a minimum of 4" square X 1 1/2" deep. For recessing in exposed masonry, provide one piece drawn 4" square x 1 1/2" deep wall boxes with appropriate 4" square cut tile wall covers. For recessing in furred-out block walls, provide 4" square box with required extension for block depth and required extension for drywall depth.
 6. Boxes shall be of such form and dimensions as to be adapted to the specific use and location, type of device or fixtures to be used, and number and size of conductors and arrangement, size and number of conduits connecting thereto.
 7. Handy boxes shall not be used for any purpose.
 8. Where a box is used as the sole support for a ceiling paddle fan, the box must be listed for this purpose and the weight of the fan.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, Type FD, with gasketed cover.
1. Interior surface outlet boxes and conduit bodies installed from 0" AFF to 90" AFF (including fire alarm device backbox) shall be the heavy cast aluminum or iron with external threaded hubs for power devices and threaded parts for low voltage devices. Trim rings shall also be of one-piece construction.
 2. Weatherproof outlet boxes shall be constructed of corrosion-resistant cast iron suited to each application and having threaded conduit hubs, cast metal faceplate with spring-hinged waterproof cap suitable configured, gasket, and corrosion-proof fasteners.
 3. Freestanding malleable iron cast boxes are to be type FSF (with flange). Cast aluminum/zinc boxes are not acceptable (Bell Boxes).

D. Floor Boxes:

1. For all slab on grade areas except wet locations and wooden floors: Cast iron or steel with epoxy paint, fully adjustable before and after the concrete pour. The cover shall provide protection from water, dirt and debris. The cover will be flanged die cast aluminum with brushed aluminum finish that will accept carpet or tile cutouts to match flooring. The box shall be capable of adapting to most power and communications needs. Provide all activations, barriers and brackets required for the particular installation. Design Selection is Wiremold RFB 4 (based on required outlets) or equal.
2. Wood Floors: Cast iron or steel fully adjustable, rectangular, multi-gang box. The cover shall provide protection from water, dirt and debris. The cover will be brass flip lids with appropriate multi gang ring to set flush with wood flooring. The box shall be capable of adapting to most power and communications needs.
3. Poke Thru's for all floor boxes in elevated slabs: Flush style round poke thru with combination power (2 duplex) and data (6 Cat6 outlets). Poke Thru shall be UL scrub water exclusion for tile and carpeted floors. Poke thru shall be maintains UL fire rated for up to 2 hour rated floors. Poke thru shall meet FBC and ADA accessibility guidelines.

E. Sheet Metal Pull and Junction Boxes: NEMA OS 1.

1. Pull and junction boxes (not in-ground type) larger than 25 square inches shall be hinged cover type with flush latches operated with screwdriver.
2. Large Pull Boxes: Boxes larger than 400 cubic inches in volume or 20 inches in any dimension:
 - a. Use continuous hinged enclosures with locking handle.
3. Exterior, damp location and wet location pull and junction boxes shall be Nema 4x stainless steel.

F. Cabinets (Control and Systems):

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Metal barriers to separate wiring of different systems and voltage.
4. Accessory feet where required for freestanding equipment.

2.7 HANDHOLES AND BOXES FOR EXTERIOR UNDERGROUND WIRING

A. Description: Concrete ring with Nema 6P box inside (All Areas)

1. Color of Frame and Cover: Gray.
2. Configuration: Concrete ring shall be designed for flush burial and have open bottom, unless otherwise indicated.
3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural traffic load rating consistent with enclosure.
4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
5. Cover Legend: Molded lettering, "ELECTRIC.", "TELEPHONE." or as indicated for each service.
6. Nema 6P box rated for direct burial enclosure shall be located inside the concrete ring for termination of conduits.
7. Handholes 36 inches wide by 36 inches long and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

PART 3 - EXECUTION

3.1 RACEWAY LOCATION INSTALLATION REQUIREMENTS

A. Underground Installations:

1. Use rigid non-metallic conduit (PVC) only unless local authority having jurisdiction or applicable codes/utility requirements, etc. require rigid steel conduit.
2. All conduits or elbows entering, or leaving the ground shall be rigid steel conduit coated with asphaltic paint.
3. All underground raceways shall be installed in accordance with the NEC except that the minimum cover for any conduit outside the building slab shall be two feet. Included under this Section shall be the responsibility for verifying finished lines in areas where raceways will be installed underground before the grading is complete.
4. Where rigid metallic conduit is installed underground as noted above it shall be coated with waterproofing black mastic before installation, and all joints shall be re-coated after installation.
5. Utilize rigid steel 90° elbows at each riser and at each change in direction. Elbows shall be coated with black mastic or PVC coating. Bond all metal elbows per NEC.
6. All underground service lateral raceways shall be protected as required by the NEC including requirements for installation of warning tape.

B. In Slab Above or on Grade:

1. Use coated rigid steel conduit or rigid non-metallic conduit.
2. Coating of metallic conduit to be black asphaltic or PVC.

C. Penetration of Slab:

1. Exposed Location subject to damage:
 - a. Where penetrating a floor in an exposed location subject to damage from underground or in slab, a black mastic coated or PVC coated galvanized rigid steel conduit shall be used.
2. Interior Location not subject to damage:
 - a. Where penetrating a floor in a location concealed in block wall and acceptable by applicable codes, rigid non-metallic conduit may be used up to first outlet box, provided outlet box is at a maximum height of 40" above finished floor.
 - b. Where penetrating a floor in location other than that above, transition to metallic conduit at the floor.

D. Outdoor Location:

1. Above Grade:
 - a. Where penetrating the finished grade, black mastic coated or PVC coated galvanized rigid steel conduit shall be used.
 - b. In general all exterior conduit runs shall be rigid steel conduit and threaded connectors as specified elsewhere.

- c. Electrical metallic tubing (thin wall) is permitted under roof, overhangs, etc. provided it is not subjected to physical damage and is not in direct contact or directly subject to exterior elements including sunlight.
 2. Metal Canopies:
 - a. Conduit runs except for canopy lighting raceways are not to be run on (top or bottom) of metal canopies roof systems. All new conduit shown on or at these areas is to be run underground. Clamp back spacers shall be used on all canopies to prevent galvanic action from dissimilar metals. Conduits installed exposed from Building structure to Metal Canopies will not be permitted.
 3. Roofs:
 - a. Conduit is not to be installed on roofs, without written authorization by A/E and the Owner for specific conditions.
 - b. When accepted by written authorization conduit shall comply with the following:
 - 1) Be PVC coated rigid galvanized metal conduit.
 - 2) All fittings, etc. are to be PVC coated.
 - 3) Conduit shall be supported above roof at least 6 inches using accepted conduit supporting devices. Refer to applicable sections of specifications on roofing, etc.
 - 4) Supports to be fastened to roof using roofing adhesive or means compatible with roofing. Confirm the method used will not void the roofing warranty. The use of pitch pockets is not acceptable.
- E. Interior Dry Locations:
 1. Concealed: Use rigid galvanized steel conduit and electrical metallic tubing. Rigid non-metallic conduit may be used inside block walls up to first outlet to a maximum of 40" A.F.F. except where prohibited by the NEC (places of assembly, etc.).
 2. Exposed: Use rigid galvanized steel or electrical metallic tubing. EMT may only be used where not subject to damage, which is interpreted by this specification to be above 90" AFF.
 3. Concealed or exposed flexible conduit:
 - a. Concealed flexible steel conduit or seal tight flexible steel conduit in lengths not longer than six (6) feet in length with a ground conductor installed in the conduit or an equipment ground conductor firmly attached to the terminating fitting at the extreme end of the flex. Exposed flexible steel conduit or seal tight flexible steel conduit shall not exceed two (2) feet in length, unless written authorization by A/E for specific conditions is granted.
- F. Interior Wet and Damp Locations:
 1. Use rigid galvanized steel conduit.
- G. Concrete Columns or Poured in-place Concrete Wall Locations:
 1. Use rigid non-metallic conduit. Penetration shall be by accepted metal raceway (i.e. metal conduit as required elsewhere in these specifications).

3.2 RACEWAY INSTALLATION

- A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- B. All bending, cutting, and reaming shall be completed with tools specifically designed for the specific use.
- C. Expansion fittings shall be installed in the following cases:
 - 1. In each conduit run wherever it crosses an expansion joint in the concrete structure; on one side of joint with its sliding sleeve end flush with joint, and with a length of bonding jumper in expansion equal to at least three times the normal width of joints.
 - 2. In each conduit run which mechanically attached to separate structures to relieve strain caused by shift on one structure in relation to the other.
 - 3. In straight conduit run above ground which is more than one hundred feet long and interval between expansion fittings in such runs shall not be greater than 100 feet.
- D. Arrange conduit to maintain headroom and present neat appearance.
- E. Provide rigid steel long radius 90 degree sweeps (bend radius of 10 times the conduit trade size diameter) for all changes in direction (vertical and horizontal) for utility conduits. Comply with all installation requirements of the utility to utilize the conduits.
- F. Utility conduits shall be buried a minimum of 36" deep to the top of the conduit.
- G. Route conduit installed above accessible ceilings or exposed to view parallel or perpendicular to walls. Do not run from point to point.
- H. Do not cross conduits in slab.
- I. Use conduit hubs to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.
- J. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- K. Complete raceway installation before starting conductor installation.
- L. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- M. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- N. Install no more than equivalent of three 90-degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use factory elbows for bends in metal conduit larger than 2 inch (50 mm) size.
- O. Provide continuous fiber polyline 1000 lb. minimum tensile strength pull string in each empty conduit except sleeves and nipples. This includes all raceways which do not have conductors furnished under this Division of the specifications. Pull cord must be fastened to prevent accidental removal.
- P. Use suitable caps to protect installed conduit against entrance of dirt and moisture.

- Q. Rigid steel box connections shall be made with double locknuts and bushings.
- R. Spare conduit stubs shall be capped and location and use marked with concrete marker set flush with finish grade. Marker shall be 6" round x 6" deep with appropriate symbol embedded into top to indicate use. Also, tag conduits in panels where originating.
- S. Spare conduit stubs shall be capped with a UL listed and accepted cap or plug for the specific intended use and identified with ink markers as to source and labeled "Spare."
- T. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- U. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
- V. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- W. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
- X. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
 - 1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 2. Where otherwise required by NFPA 70.
- Y. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
- Z. All raceway runs in masonry shall be installed at the same time as the masonry so that no face cutting is required, except to accommodate boxes.
- AA. Raceways shall not be routed through stairwells, elevator shafts, elevator machine rooms or fire pump rooms unless the conduit is for use within that space.
- BB. Raceways installed in hazardous locations shall be installed in accordance with the appropriate provisions of NEC chapter 5 for that location. Confirm the appropriate space rating with life safety plans.
- CC. All raceway runs, whether terminated in boxes or not, shall be capped during the course of construction and until wires are pulled in, and covers are in place. No conductors shall be pulled into raceways until construction work which might damage the raceways has been completed.
- DD. Electrical raceways shall be supported independently of all other systems and supports, and shall in every case avoid proximity to other systems which might cause confusion with such systems or might provide a chance of electrolytic actions, contact with live parts or excessive induced heat.

- EE. Excavate trench bottom to provide firm and uniform support for conduit installed underground. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter. Install backfill as specified in Division 31 Section "Earth Moving."
- FF. After installing underground conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."

3.3 BOX INSTALLATION

- A. Set metal floor boxes level and flush with finished floor surface.
- B. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- C. Install electrical boxes as shown on drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.
- D. Install electrical boxes to maintain headroom and to present neat mechanical appearance.
- E. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches (150 mm) from ceiling access panel or from removable recessed luminaire.
- F. Install boxes to preserve fire resistance rating of partitions and other elements.
- G. Align adjacent wall-mounted outlet boxes for switches, thermostats, and similar devices with each other.
- H. Outlets for 120V clocks shall be recessed so that the clock will hang flush with the finished surface of the wall.
- I. Use flush mounting outlet boxes in finished areas.
- J. Do not install flush mounting boxes back-to-back in walls; provide minimum 6 inch (150 mm) separation. Provide minimum 24 inches (600 mm) separation in acoustic and fire rated walls.
- K. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
- L. Use stamped steel bridges to fasten flush mounting outlet box between studs.
- M. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
- N. Support all outlet boxes from structure with minimum of one (1) 3/8" all-thread rod hangers. Boxes larger than 25 square inches shall be supported with two (2) all-thread rod hangers, minimum.
- O. Do not fasten boxes to ceiling support wires.

- P. Use multi-gang box where more than one device is mounted together. Do not use sectional box.
- Q. Boxes in exterior walls shall be flush mounted. Use cast outlet box in exterior locations and wet locations where flush mounting is not possible.
- R. Install outlets in the locations shown on the drawings; however, the Owner shall have the right to make, prior to rough-in, slight changes in locations to reflect room furniture layouts.
- S. Coordinate work with all divisions so that each electrical box is the type suitable for the wall or ceiling construction provided and suitable fireproofing is inbuilt into fire rated walls.
- T. All boxes shall be installed in a flush rigid manner with box lines at perpendicular and parallel angles to finished surfaces. Boxes shall be supported by appropriate hardware selected for the type of surface from which the box shall be supported. For example, provide metal screws for metal, wood screws for wood, and expansion devices for masonry or concrete.
- U. For locations exposed to weather or moisture (interior or exterior), provide weatherproof boxes and accessories.
- V. As a minimum, provide pull boxes in all raceways over 150 feet long. The pull box shall be located near the midpoint of the raceway length.
- W. Provide knockout closures to cap unused knockout holes where blanks have been removed, and plugs for unused threaded hubs.
- X. Provide conduit locknuts and bushings of the type and size to suit each respective use and installation.
- Y. Boxes and conduit bodies shall be located so that all electrical wiring is accessible.
- Z. Avoid using round boxes where conduit must enter box through side of box, which would result in a difficult and insecure connection with a locknut or bushing on the rounded surface.
- AA. All flush outlets shall be mounted so that covers and plates will finish flush with finished surfaces without the use of shims, mats or other devices not submitted or accepted for the purpose. Add-a-Depth rings or switch box extension rings are not acceptable. Plates shall not support wiring devices. Gang switches with common plate where two or more are indicated in the same location. Wall-mounted devices of different systems (switches, thermostats, etc.) shall be coordinated for symmetry when located near each other on the same wall. Outlets on each side of walls shall have separate boxes. Through-wall type boxes shall not be permitted. Back-to-back mounting shall not be permitted. Trim rings shall be extended to within 1/8" of finish wall surface.
- BB. Outlet boxes mounted in metal stud walls, are to be supported to studs with two (2) screws inside of outlet box to a horizontal stud brace between vertical studs or one side of outlet box supported to stud with opposite side mounted to section of stud or device to prevent movement of outlet box after wall finished.
- CC. All outlet boxes that do not receive devices in this contract are to have blank plates installed matching wiring device plates.

DD. Height of wall outlets to bottom above finished floors shall be as follows, unless specifically noted otherwise, or unless otherwise required by applicable codes including ADA. Verify with the Architectural plans and shop drawings for installing.

- | | | |
|----|--------------------------|---|
| 1. | Switches | 4'-0" AFF to top |
| 2. | Receptacles | 1'-4" AFF to bottom |
| 3. | Lighting Panels | 6'-6" AFF to centerline of highest breaker/fuse |
| 4. | Phone outlets | 1'-4" AFF to bottom |
| 5. | Intercom Call-in | 4'-0" AFF to top |
| 6. | Fire Alarm Pull Stations | 4'-0" AFF to top |
| 7. | Fire Alarm Strobe Lights | Lens is not less than 80" AFF and not more than 96" AFF |
| 8. | Fire Alarm Audible Only | Not less than 90" and not less than 6" below ceiling. |

EE. Bottoms of outlets above counter tops or base cabinets shall be minimum 2" above counter top or backsplash, whichever is highest. Outlets may be raised so that bottom rests on top of concrete block course, but all outlets above counters in same area shall be at same height. It is the responsibility of this Division to secure cabinet drawings and coordinate outlet locations in relation to all cabinets as shown on Architectural plans, prior to rough-in, regardless of height shown on Division 26 drawings.

FF. Height of wall-mounted fixtures shall be as shown on the drawings or as required by Architectural plans and conditions. Fixture outlet boxes shall be equipped with fixture studs when supporting fixtures.

GG. Locate special purpose outlets as indicated on the drawings for the equipment served. Location and type of outlets shall be coordinated with appropriate trades involved. The securing of complete information for proper electrical roughing-in shall be included as work required under this section of specifications. Provide plug for each outlet.

HH. Electrical outlet boxes may be installed in vertical fire resistive assemblies classified as fire/smoke and smoke partitions without affecting the fire classification, provided such openings occur on one side only within a 24" wall space and that openings do not exceed 16 sq. inches. All clearances between such outlet boxes and the gypsum board must be completely filled with joint compound.

II. Fire-Barrier Penetrations: Firestop penetrations under division 07 Section "Firestopping".

3.4 INSTALLATION OF UNDERGROUND HANDHOLES AND BOXES

A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.5-mm) sieve to No. 4 (4.75-mm) sieve and compacted to same density as adjacent undisturbed earth.

C. Elevation: In all areas, set so cover surface will be flush with finished grade.

3.5 INSTALLATION OF WIREWAYS

- A. Do not install wireways as a substitute for proper coordination and layout of conduit stub ups to panels. Prior authorization from the engineer is required prior to installation of any wireways.
- B. Do not make splices in wireways. All wires must be pulled through without splice or termination.
- C. Install wireway to maintain headroom and to present neat mechanical appearance.
- D. Support wireway independently of conduit.
- E. Wireway shall be located so that all electrical wiring is accessible.

END OF SECTION 26 05 33

SECTION 26 05 53 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Identification for raceway and metal-clad cable.
 - 2. Identification for conductors and communication and control cable.
 - 3. Underground-line warning tape.
 - 4. Warning labels and signs.
 - 5. Instruction signs.
 - 6. Equipment identification labels.
 - 7. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.
- B. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.
- C. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 RACEWAY, BOX AND METAL-CLAD CABLE IDENTIFICATION MATERIALS

- A. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeves, 2 inches (50 mm) long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- B. Primed and Painted band 4" in length.

2.2 CONDUCTOR AND COMMUNICATION- AND CONTROL-CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.3 UNDERGROUND-LINE WARNING TAPE

- A. Description: Permanent, bright-colored, continuous-printed, polyethylene tape.
 - 1. Not less than 6 inches (150 mm) wide by 4 mils (0.102 mm) thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend shall indicate type of underground line.

2.4 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- C. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- D. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."

2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.5 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. in. (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 1. Engraved legend with black letters on white face.
 2. Punched or drilled for mechanical fasteners.
 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.6 EQUIPMENT IDENTIFICATION LABELS

- A. Safety Signs: Comply with 29 CFR, 1910.145.
- B. Nameplates shall be laminated phenolic plastic, chamfer edges.
 1. For 120/208 Volt System:
 - a. Black front and back with white core, with lettering etched through the outer covering. White engraved letters on Black background.
 2. For 277/480 Volt System:
 - a. Orange front and back with white core with lettering etched through the outer covering. White engraved letters on Orange background.
 3. For Emergency System:
 - a. Red front and back with white core with lettering etched through the outer covering. White engraved letters on red background.

2.7 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Cable Ties: Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
 1. Minimum Width: 3/16 inch (5 mm).
 2. Tensile Strength: 50 lb (22.6 kg), minimum.
 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 4. Color: Black, except where used for color-coding.
- B. Paint: Paint materials and application requirements are specified in Division 09 painting Sections.
- C. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Identification Materials and Devices: Install at locations for most convenient viewing without interference with operation and maintenance of equipment.
- B. Lettering, Colors, and Graphics: Coordinate names, abbreviations, colors, and other designations with corresponding designations in the Contract Documents or with those required by codes and standards. Use consistent designations throughout Project.
- C. Sequence of Work: If identification is applied to surfaces that require finish, install identification after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before applying.
- E. Install painted identification according to manufacturer's written instructions and as follows:
 - 1. Clean surfaces of dust, loose material, and oily films before painting.
 - 2. Prime surfaces using type of primer specified for surface.
 - 3. Apply one intermediate and one finish coat of enamel.
- F. Caution Labels for Indoor Boxes and Enclosures for Power and Lighting: Install pressure-sensitive, self-adhesive labels identifying system voltage with black letters on orange background. Install on exterior of door or cover.
- G. Circuit Identification Labels on Boxes: Install labels externally.
 - 1. Exposed Boxes: Pressure-sensitive, self-adhesive plastic label on cover.
 - 2. Concealed Boxes: Plasticized card-stock tags.
 - 3. Labeling Legend: Permanent, waterproof listing of panel and circuit number or equivalent.
- H. Paths of Underground Electrical Lines: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed in a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install line marker for underground wiring, both direct-buried cables and cables in raceway.
- I. Secondary Service, Feeder, and Branch-Circuit Conductors: Color-code throughout the secondary electrical system.
 - 1. Color-code 208/120-V system as follows:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - f. Switchlegs(load side of contactor or relay is not considered a switchleg): Purple
 - 2. Color-code 480/277-V system as follows:

- a. Phase A: Brown
 - b. Phase B: Orange
 - c. Phase C: Yellow
 - d. Neutral: White with a colored stripe or gray.
 - e. Ground: Green.
 - f. Switchleg(load side of contactor or relay is not considered a switchleg): Pink
3. Factory apply color the entire length of conductors, except the following field-applied, color-coding methods may be used instead of factory-coded wire for sizes larger than No. 6 AWG:
 - a. Colored, pressure-sensitive plastic tape in half-lapped turns for a distance of 6 inches from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Use 1-inch wide tape in colors specified. Adjust tape bands to avoid obscuring cable identification markings.
- J. Power-Circuit Identification: Metal tags or aluminum, wraparound marker bands for cables, feeders, and power circuits in vaults, pull and junction boxes, manholes, and switchboard rooms.
1. Legend: 1/4-inch steel letter and number stamping or embossing with legend corresponding to indicated circuit designations.
 2. Tag Fasteners: Nylon cable ties.
 3. Band Fasteners: Integral ears.
- K. Apply identification to conductors as follows:
1. Conductors to Be Extended in the Future: Indicate source and circuit numbers.
 2. Multiple Power or Lighting Circuits in the Same Enclosure: Identify each conductor with source, voltage, circuit number, and phase. Use color-coding to identify circuits' voltage and phase.
 3. Multiple Control and Communication Circuits in the Same Enclosure: Identify each conductor by its system and circuit designation. Use a consistent system of tags, color-coding, or cable marking tape.
- L. Apply warning, caution, and instruction signs as follows:
1. Warnings, Cautions, and Instructions: Install to ensure safe operation and maintenance of electrical systems and of items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
 2. Emergency Operation: Install engraved laminated signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, and other emergency operations.
- M. Equipment Requiring Workspace Clearance According to NFPA 70: Unless otherwise indicated, apply to door or cover of equipment but not on flush panelboards and similar equipment in finished spaces.
- N. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction

- signs with approved legend where instructions are needed for system or equipment operation.
2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer.
- O. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
1. Labeling Instructions:
 - a. Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.
 - b. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
 2. Equipment to Be Labeled: Include as a minimum the equipment identification (first line 1/2"); voltage rating and amperage rating (second line 3/8"); where it is fed from (third line 3/8"). (Example :Panel CP1 (Line 1), 208/120V 3ph, 4w, 225A(line 2), fed from swbd MDP-1 (Line 3))
 - a. Panelboards, electrical cabinets, and enclosures.
 - b. Access doors and panels for concealed electrical items.
 - c. Electrical switchgear and switchboards.
 - d. Transformers.
 - e. Electrical substations.
 - f. Emergency system boxes and enclosures.
 - g. Motor-control centers.
 - h. Disconnect switches.
 - i. Enclosed circuit breakers.
 - j. Motor starters.
 - k. Push-button stations.
 - l. Power transfer equipment.
 - m. Contactors.
 - n. Remote-controlled switches, dimmer modules, and control devices.
 - o. Battery inverter units.
 - p. Battery racks.
 - q. Power-generating units.
 - r. Voice and data cable terminal equipment.
 - s. Master clock and program equipment.
 - t. Intercommunication and call system master and staff stations.
 - u. Television/audio components, racks, and controls.
 - v. Fire-alarm control panel and annunciators.
 - w. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
 - x. Monitoring and control equipment.
 - y. Uninterruptible power supply equipment.
 - z. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.2 SWITCHGEAR BREAKERS

- A. Provide labels for each breaker to identify the load served.

3.3 CONDUIT/JUNCTION BOX COLOR CODE

- A. All conduit system junction boxes (except those subject to view in public areas) shall be color coded as listed below:

- B. Color Code for Junction Boxes

1.	System Emergency 277/480 volt	Orange/Brown
2.	System Emergency 120/208 volt	Orange/Black
3.	Fire Alarm	Red
4.	Normal Power 277/480 volt	Brown
5.	Normal Power 120/208 volt	Black
6.	Fiber Optics	Purple
7.	Sound System	Yellow
8.	Clock	Light Blue
9.	Intercom	Blue
10.	Computer/Data	Gold
11.	TV	White
12.	Security/CCTV	Beige
13.	Ground	Fluorescent Green
14.	Telephone	Clover Green

- C. Conduits (not subject to public view) longer than 20 feet shall be painted with above color paint band 20 ft. on center. Paint band shall be 4" in length, applied around the entire conduit. Where conduits are parallel and on conduit racking, the paint bands shall be evenly aligned. Paint shall be neatly applied and uniform. Paint boxes and raceways prior to installation or tape conduits and surrounding surfaces to avoid overspray. Paint overspray shall be removed.

- D. All new and existing junction boxes/cover plates for power, lighting and systems (except those installed in public areas) shall adequately describe it's associated panel and circuit reference number(s) within, (i.e. ELRW-2, 4, 6) or systems within (i.e. fire alarm, intercom. Etc.). Identification shall be by means of black permanent marker. (Paint ½ cover plate with appropriate color as noted in 2.3 above, and mark other ½ with associated panel/circuit or system description as described).

END OF SECTION 26 05 53

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SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Twist-locking receptacles.
 - 3. Isolated-ground receptacles.
 - 4. Snap switches and wall-box dimmers.
 - 5. Solid-state fan speed controls.
 - 6. Pendant cord-connector devices.
 - 7. Cord and plug sets.
 - 8. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

1.3 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. TVSS: Transient voltage surge suppressor.
- F. UTP: Unshielded twisted pair.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Comply with NEMA WD 1.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

1.7 ALLOWANCES

- A. Provide for twenty additional receptacles as directed in field. Allowance includes purchase, delivery and installation of box, receptacle cover plate, wire and 100 feet of conduit for each receptacle.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 2. Leviton Mfg. Company Inc. (Leviton).
 - 3. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.2 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following for standard convenience outlets:
 - a. Hubbell; HBL5361 (single), HBL5352 (duplex).
 - b. Leviton; 5351 (single), 5352 (duplex).
 - c. Pass & Seymour; 5361 (single), 5352 (duplex).

2. Black Computer Power Duplex Receptacle:
 - a. Pass & Seymour Model PS5352-Black
 - b. Hubbell Model HBL5362-Black
 - c. Leviton Model 5362-Black

2.3 GFCI RECEPTACLES

- A. General Description: Straight blade, feed-through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and trip button to indicate when device is tripped. Face will not have power if reverse wired. Visual indication for device has lost capability to provide protection.
- B. Outdoor locations provide weather resistant GFCI convenience receptacles, 125V, 20A - Black
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell #GFR5362WR
 - b. Pass & Seymour; 2095DSWRBK.
 - c. Leviton #W7899-E
- C. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell #GFR5362
 - b. Pass & Seymour; 2095.
 - c. Leviton #6898

2.4 HAZARDOUS (CLASSIFIED) LOCATION RECEPTACLES

- A. Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper Crouse-Hinds.
 - b. EGS/Appleton Electric.
 - c. Killark; a division of Hubbell Inc.

2.5 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL2310.
 - b. Leviton; 2310.
 - c. Pass & Seymour; L520-R.

2.6 PENDANT CORD-CONNECTOR DEVICES

- A. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
1. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
 2. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.7 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
 2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.8 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Snap switches for general use shall be maintained contact types, and shall be single-pole, double-pole, three-way, or four-way as required for the specific switching arrangements shown on the drawings. They shall be quiet tumbler operation types, having silver alloy contacts, and meeting all NEMA performance standards.
- C. Switches, 120/277 V, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1221 (single pole), HBL1222 (two pole), HBL1223 (three way), HBL1224 (four way).
 - b. Leviton; 1221 (single pole), 1222 (two pole), 1223 (three way), 1224 (four way).
 - c. Pass & Seymour; PS20AC1 (single pole), PS20AC2 (two pole), PS20AC3 (three way), PS20AC4 (four way).
- D. Pilot Light Switches, 20 A:
1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HPL1221PL for 120 V and 277 V.
 - b. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - c. Pass & Seymour; PS20AC1RPL for 120 V.
 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "off." Provide red handle for switches connected to emergency power.

- E. Key-Operated Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1221L.
 - b. Leviton; 1221L.
 - c. Pass & Seymour; PS20AC1-L.
 - 2. Description: Single pole, with factory-supplied key in lieu of switch handle. All key operated switches shall be keyed alike.
- F. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1557.
 - b. Leviton; 1257.
 - c. Pass & Seymour; 1251.
- G. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle. All keyed switches shall be keyed alike.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; HBL1557L.
 - b. Leviton; 1257L.
 - c. Pass & Seymour; 1251L.

2.9 WALL-BOX DIMMERS

- A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
- B. Control: Continuously adjustable toggle switch; with single-pole or three-way switching. Comply with UL 1472.
- C. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
 - 1. 600 W; dimmers shall require no derating when ganged with other devices.
- D. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

2.10 FAN SPEED CONTROLS

- A. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.

1. Continuously adjustable toggle switch, 5 A.
2. Three-speed adjustable slider, 1.5 A.

2.11 WALL PLATES

- A. Single and combination types to match corresponding wiring devices.
1. Plate-Securing Screws: Metal with head color to match plate finish.
 2. All wiring devices shall be provided with standard size one-piece cover plates of suitable configuration for the number and type of devices to be covered.
 3. Metallic cover plates shall be used in interior spaces, except as noted below, and shall be fabricated of corrosion-resistant #302 stainless steel, having a nominal thickness of .04", and a brushed finish. Screws securing the plates shall have flush (when installed) heads with finish to match plates. Metallic cover plates shall meet all requirements of the National Electrical Code and Federal Specifications.
 4. Cover plates for switches located in corrosive atmospheres (where vaporproof is not indicated) shall be equal to Hubbell #17CM81/#17CM82/#17CM83/#17CM84 one piece neoprene with matching pressswitch.
 5. Cover plate engraving, where required, shall be accomplished by cover plate manufacturer in accordance with instructions given on the drawings. Metallic plates shall be engraved with black fill. Red plates shall be engraved with white fill.
 6. Material for Unfinished Spaces: Galvanized steel.
- B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum with lockable "in use" cover. Cover plates for exterior receptacles shall be gasketed covers with hinge allowing plug and cord to be plugged in and activated with cover closed..

2.12 MULTIOUTLET ASSEMBLIES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Incorporated; Wiring Device-Kellems.
 2. Wiremold Company (The).
 3. Mono-systems, Inc.
- B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
- C. Raceway Material: Metal, with manufacturer's standard finish.
- D. Wire: No. 12 AWG.

2.13 SERVICE POLES

- A. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.

1. Poles: Nominal 2.5-inch- (65-mm-) square cross section, with height adequate to extend from floor to at least 6 inches (150 mm) above ceiling, and with separate channels for power wiring and voice and data communication cabling.
2. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
3. Finishes: Manufacturer's standard painted finish and trim combination.
4. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
5. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
6. Voice and Data Communication Outlets: Four RJ-45 Category 6 jacks.

2.14 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
1. Wiring Devices Connected to Normal Power System: Gray in unfinished spaces and Ivory in finished spaces, unless otherwise noted.
 2. Receptacle devices for computer power shall be black color.
 3. Wiring Devices Connected to Emergency Power System: Red.
 4. Modify any given catalog numbers as required to procure devices and plates of the proper color.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Coordination with Other Trades:
1. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 4. Install wiring devices after all wall preparation, including painting, is complete.
- B. Install products in accordance with manufacturer's instructions.
- C. Install devices plumb and level.
- D. Install switches with OFF position down.
- E. Provide device coverplates for every device installed. Cover plates shall be installed so that they appear straight with no gaps between plate edges and the wall. Maintain vertical and horizontal to within 1/16 of an inch
- F. Wiring devices shall not be installed in exposed masonry until cleaning of masonry with acids has been completed.

- G. All receptacles and switches shall be grounded by means of a ground wire from device ground screw to outlet box screw and branch circuit ground conductor. Strap alone will not constitute an acceptable ground.
- H. All devices shall be installed so that only one wire is connected to each terminal.
- I. Connect wiring devices by wrapping conductor around screw terminal.
- J. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
- K. Install local room area wall switches at door locations on the lock side of the door, approximately four inches from the jamb. Where locations shown on the drawings are in question, provide written request for information to A/E prior to roughin.
- L. Conductors:
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- M. Device Installation:
 - 1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
 - 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 - 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 - 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - 8. Tighten unused terminal screws on the device.
 - 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- N. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
- O. Dimmers:
 - 1. Install dimmers within terms of their listing.
 - 2. Verify that dimmers used for fan speed control are listed for that application.
 - 3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

- P. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on bottom. Group adjacent switches or receptacles under multigang wall plates. Provide proper NEC barriers in boxes which serve devices for both the Normal and Emergency Systems.
- Q. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 CONNECTIONS

- A. Connect wiring device grounding terminal to outlet box with bonding jumper.
- B. Connect wiring device grounding terminal to branch-circuit equipment grounding conductor.
- C. Tighten electrical connectors and terminals according to manufacturers published torque-tightening values. If manufacturers torque values are not indicated, use those specified in UL 486A and UL 486B.

3.3 NEUTRAL CONDUCTOR CONNECTIONS

- A. At each receptacle "in" and "out" phase and neutral conductors shall have an additional conductor for connection to device. The practice of "looping" conductors through receptacle boxes shall not be acceptable. (IE: The device shall not be used to complete the circuit. Pigtails shall be used from the device)

3.4 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
 - 1. Receptacles and Switches: Identify panelboard and circuit number from which served. Use permanent marker to identify on the back of plates or tags within outlet boxes.

3.5 FIELD QUALITY CONTROL

- A. Inspect each wiring device for defects.
- B. Operate each wall switch with circuit energized and verify proper operation.
- C. Verify that each receptacle device is energized.
- D. Test each receptacle device for proper polarity.
- E. Test each GFCI receptacle device for proper operation.

3.6 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

END OF SECTION 26 27 26

SECTION 26 28 16 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following individually mounted, enclosed switches and circuit breakers:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Bolted-pressure contact switches.
 - 4. High-pressure, butt-type contact switches.
 - 5. Molded-case circuit breakers.
 - 6. Molded-case switches.
 - 7. Enclosures.

1.3 DEFINITIONS

- A. GD: General duty.
- B. GFCI: Ground-fault circuit interrupter.
- C. HD: Heavy duty.
- D. RMS: Root mean square.
- E. SPDT: Single pole, double throw.

1.4 REFERENCES

- A. UL 98 Enclosed and Dead Front Switches
- B. NEMA KS1 Enclosed Switches
- C. NEMA 250 Enclosures for Electrical Equipment
- D. NFPA 70 National Electric Code

1.5 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current rating.
 - 4. UL listing for series rating of installed devices.
 - 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current curves, including selectable ranges for each type of circuit breaker.

1.6 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with NFPA 70.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 - 2. Altitude: Not exceeding 6600 feet (2010 m).

1.8 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.2 RATING

- A. The size, number of poles, and fusing for each switch shall be as denoted on the drawings. As a minimum, no less than one pole for each ungrounded conductor shall be provided. Switches shall be rated 250 VAC or 600 VAC as required by the circuit to which it is connected.
- B. Switches serving motors with more than one set of windings shall have the number of poles necessary to disconnect all conductors to all windings in a single switch. Switches serving motor loads shall be horsepower rated of sufficient size to handle the load.
- C. Switches shall be rated for the available fault current at that location. Provide enclosed circuit breakers if required to meet the available fault current. If the available fault current is unknown, assume that the available fault current is to be equal to the upstream panel fault current.

2.3 SERVICE ENTRANCE EQUIPMENT

- A. Switches used as service entrance equipment shall be listed and labeled by U.L. for use as service equipment.

2.4 FUSIBLE AND NONFUSIBLE SWITCHES

- A. Manufacturers:
 - 1. Eaton Corporation; Cutler-Hammer Products.
 - 2. General Electric Co.; Electrical Distribution & Control Division.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D/Group Schneider.
- B. Fusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Nonfusible Switch, 1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- D. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.

3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.5 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Siemens Energy & Automation, Inc.
4. Square D/Group Schneider.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic Trip-Unit Circuit Breakers: All breakers 400A and larger. RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with 5-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
5. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage with field-adjustable 0.1- to 0.6-second time delay.
7. Auxiliary Switch: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
9. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.6 ENCLOSURES

- A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.
- B. All switches shall be firmly anchored to walls and supporting structures (where used) using appropriate installation. Switches shall be installed with the turning axis of their handles approximately 5'-0" above finished floor unless otherwise indicated. Provide rigid steel (galvanized for exterior use) mounting stands, brackets, plates, hardware, and accessories for a complete installation
- C. Switches shall be mounted in accessible locations chosen where the passageway to the switch is not likely to become obstructed. Where a switch serves as the disconnecting means for a load, the switch shall be located as close as practical to the load with the switch handle within sight of the load.
- D. Provide and install lugs on disconnect switch as required to accept conductors called for on drawings.
- E. Disconnect switches shall not be mounted on equipment, unless specifically noted or required and meet all applicable codes, etc. If switches are noted or required to be mounted on equipment they shall have vibrator clips on fuses and be connected to conduit system with liquid tight flexible conduit.
- F. Coordinate all requirements for controls between variable speed drive units and its respective motor with drive specification, manufacturer, provider and installer. Provide auxiliary contacts, relays, etc. as required.
- G. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification for Electrical Systems."
- B. Enclosure Nameplates: Label each enclosure with engraved metal or laminated-plastic nameplate as specified in Division 26 Section "Identification for Electrical Systems."

3.4 CONNECTIONS

- A. Install equipment grounding connections for switches with ground continuity to main electrical ground bus.
- B. Install power wiring. Install wiring between switches and control and indication devices.
- C. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

- A. Prepare for acceptance testing as follows:
 - 1. Inspect mechanical and electrical connections.
 - 2. Verify switch and relay type and labeling verification.
 - 3. Verify rating of installed fuses.
 - 4. Inspect proper installation of type, size, quantity, and arrangement of mounting or anchorage devices complying with manufacturer's certification.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Infrared Scanning:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Open or remove doors or panels so connections are accessible to portable scanner.
 - b. Instruments, Equipment and Reports:
 - 1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
 - 2) Prepare a certified report that identifies enclosed switches and circuit breakers included and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.6 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.7 CLEANING

- A. On completion of installation, vacuum dirt and debris from interiors; do not use compressed air to assist in cleaning.
- B. Inspect exposed surfaces and repair damaged finishes.

END OF SECTION 26 28 16

SECTION 26 29 23 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Surge Protection Devices" for low-voltage power, control, and communication surge suppressors.

1.3 DEFINITIONS

- A. BMS: Building management system.
- B. IGBT: Integrated gate bipolar transistor.
- C. LAN: Local area network.
- D. PID: Control action, proportional plus integral plus derivative.
- E. PWM: Pulse-width modulated.
- F. VFC: Variable frequency controller.

1.4 SUBMITTALS

- A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.
- B. Shop Drawings: For each VFC.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short-circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.

- e. Features, characteristics, ratings, and factory settings of each motor-control center unit.
2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Routine maintenance requirements for VFCs and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- F. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

- A. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NFPA 70.
- D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.
- B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
 - 1. Ambient Temperature: 0 to 40 deg C.
 - 2. Humidity: Less than 90 percent (noncondensing).
 - 3. Altitude: Not exceeding 3300 feet (1005 m).
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Eaton Corporation; Cutler-Hammer Products.
 - 3. General Electric Company; GE Industrial Systems.
 - 4. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
 - 5. Siemens Energy and Automation; Industrial Products Division.
 - 6. Square D.
 - 7. Emerson Electric
 - 8. Toshiba International Corporation.
 - 9. Trane

2.2 GENERAL

- A. Short Circuit Withstand Rating: All variable frequency controllers shall have a short circuit withstand rating identical or higher than the upstream panel or switchgear that it is connected. Rating shall be permanently marked on the VFC.

2.3 VARIABLE FREQUENCY CONTROLLERS

- A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
- B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- C. Unit Operating Requirements:
1. Input ac voltage tolerance of 208 V, plus or minus 5 percent and 380 to 500 V, plus or minus 10 percent.
 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 4. Minimum Displacement Primary-Side Power Factor: 96 percent.
 5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 6. Starting Torque: 100 percent of rated torque or as indicated.
 7. Speed Regulation: Plus or minus 1 percent.
- D. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
1. Electrical Signal: 4 to 20 mA at 24 V.
- E. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 2 to a minimum of 22 seconds.
 4. Deceleration: 2 to a minimum of 22 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- F. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.
 4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.

- G. Memory: Controller shall permanently maintain all input data including but not limited to motor data, trip parameters, time/date, fault log, etc. Battery may be used for time date ride thru of power outage for a minimum of 72hours.
- H. Multiple-Motor Capability: Controller suitable for service to multiple motors and having a separate overload relay and protection for each controlled motor. Overload relay shall shut off controller and motors served by it when overload relay is tripped.
- I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
 - 1. Power on.
 - 2. Run.
 - 3. Overvoltage.
 - 4. Line fault.
 - 5. Overcurrent.
 - 6. External fault.
- M. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- N. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
 - 1. Output frequency (Hz).
 - 2. Motor speed (rpm).
 - 3. Motor status (running, stop, fault).
 - 4. Motor current (amperes).
 - 5. Motor torque (percent).
 - 6. Fault or alarming status (code).
 - 7. PID feedback signal (percent).
 - 8. DC-link voltage (VDC).
 - 9. Set-point frequency (Hz).
 - 10. Motor output voltage (V).
- O. Control Signal Interface:
 - 1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 - 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.

- c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
3. Output Signal Interface:
- a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
- a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- P. Line Reactor: Provide drive with UL listed 5% input line reactor to help prevent drive component damage, reduce nuisance tripping caused by utility capacitor switching and provide harmonic mitigation. Reactor shall be TCI KDR high Z or equal.
- Q. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- R. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).
- S. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.
- T. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker with lockable handle.
- U. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
- V. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.4 ENCLOSURES

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 4X.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4x.
 - 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.5 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Standard Displays:
 - 1. Output frequency (Hz).
 - 2. Set-point frequency (Hz).
 - 3. Motor current (amperes).
 - 4. DC-link voltage (VDC).
 - 5. Motor torque (percent).
 - 6. Motor speed (rpm).
 - 7. Motor output voltage (V).
- F. Historical Logging Information and Displays:
 - 1. Real-time clock with current time and date.
 - 2. Running log of total power versus time.
 - 3. Total run time.
 - 4. Fault log, maintaining last four faults with time and date stamp for each.
- G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

2.6 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.
- B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

- A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.
- B. Install VFCs larger than 9 cubic feet on concrete bases.
- C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

3.4 IDENTIFICATION

- A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.

3.6 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
 - 3. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each visual and mechanical inspection, except optional tests, stated in NETA ATS.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.8 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain variable frequency controllers. Refer to Division 01 Section "Demonstration and Training."

3.10 WARRANTY

- A. Provide 1 year parts and labor warranty.

END OF SECTION 26 29 23

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