COFFMAN ENGINEERS

USDA

# MAB Building 6403 Renovation

# FINAL TURNOVER SUBMITTAL

October 17, 2025

CEI Project No. 212431

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# INTRODUCTION

The Arthropod Containment Facility (Building 6403) at Moore Air Base has aging equipment and building components that need replacement. The building laboratory spaces require modifications to the floor area, cabinetry, and ventilation for operational requirements and to meet mission capabilities.

## Scope Items

The scope and phasing of this project, as developed through the pre-design and design phases, is as follows:

Base Bid scope items:

1. Completely replace the chilled water system with all new air-cooled chillers, pumps, controls, piping, and accessories. New piping will be routed on top of the building roof instead of exposed in the occupied spaces.
2. Remove and replace all of the existing air handling units and exhaust fans throughout the facility. Replace all ductwork and grilles, registers, and diffusers throughout the building.
3. Replace the entire building DDC controls system.
4. Completely replace the steam boiler system including the associated feedwater treatment system, appurtenances, piping, etc.
5. Remove abandoned mechanical piping throughout the facility.
6. Replace the ceiling tile and lighting in all occupied rooms of the facility except for the 4 rooms identified as Alternate 01.
7. Completely replace the building roofing to include the roof soffits and gutters. Install new fall protection rail along the roof perimeter where mechanical equipment is within ten feet of the roof edge.
8. Access control, door, and door hardware modifications and replacements throughout the building.
9. Remodel the entry and bathroom areas to reduce the number of showers and provide locker space for employees. New plumbing fixtures, door and wall locations, ceilings, floors, and lighting.
10. Install new air curtains at laboratory access points.
11. Remodel Laboratory Rm 114 and infill the existing emergency exit. Install a new fume hood, a new emergency shower, and new floor drain in the room.
12. Install a new 100% outside air energy recovery unit to serve laboratory systems, complete with new ductwork, flow control valves and reheat coils for zone control.
13. Replace flooring in laboratory rooms and head house.
14. Replace casework and modify electrical in laboratory rooms 114, 101, and 107. Replace sinks and install new point-of-use instant water heaters at the sink locations.
15. Install a new steam capture hood over the existing autoclave.
16. Install new drainage piping for the sink in the headhouse. Install a new RO pipe and faucet for this sink. Install a detachable drench hose at the sink.
17. Install a new bottle filler drinking fountain in the headhouse.

Alternate 01:

1. Replace the flooring, wall base, lighting, and lighting controls in Autoclave, Passageway, Test Intake, and Test rooms. Repair ceiling damage and repaint all of these rooms.

Alternate 02:

1. Demo the exterior electrical panelboard by the greenhouses.
2. Repaint the entire building exterior.

Alternate 03:

1. Repair the six environmental growth chambers to include new controls, pumps, stands, and connections to the building chilled water and steam systems.

Alternate 04:

1. Remove existing door, frame and hardware from Maintenance 105 and infill the opening. Install new door and doorway on north wall of room.

# Project Specifications

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SECTION 011000 - SUMMARY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Project information.
2. Work covered by Contract Documents.
3. Contractor's use of site and premises.
4. Coordination with occupants.
5. Work restrictions.
6. Specification and Drawing conventions.

B. Related Requirements:

1. Section 015000 "Temporary Facilities and Controls" for limitations and procedures governing temporary use of Owner's facilities.

1.2 PROJECT INFORMATION

A. Project Location: U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), Plant Protection Quarantine (PPQ), Science and Technology (S&T), Arthropod Containment Building 6403.
Moore Air Base
Building 6403
22675 N. Moorefield Rd.
Edinburg, TX 78541

B. Owner: USDA Moore Air Base.

1. Contracting Officer (CO): Jim Roloff.
2. Contracting Officers Representative (COR): see Owner contract specifications.
3. Program Project Manager (PPM): Ralph O'Neal.
4. Engineering Project Manager (EPM): Toni Mitchell.

C. Engineer: Coffman Engineers, Inc.

1. Engineer's Representative: Parker Matthews, PE, Coffman Engineers, Inc.

D. Designer of Record: Coffman Engineers. Coffman has prepared the Contract Documents:

## 1.3 WORK COVERED BY CONTRACT DOCUMENTS

A. The Work of Project is defined by the Contract Documents and consists of the following:
Project Background: Building 6403 has a failing chiller plant and aging mechanical equipment. Laboratory spaces are not sufficient for the work performed in the building, and the mechanical HVAC system insufficient for providing the pressure zones required to meet ARS standards.

## 1.4 CONTRACTOR'S USE OF SITE AND PREMISES

A. Limits on Use of Site: Limit use of Project site to areas within the Contract limits indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.

1. Limits on Use of Site: Confine construction operations to building exterior unless otherwise requested for approval.

2. Driveways, Walkways, and Entrances: Keep driveways 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 for storage of materials.

B. Condition of Existing Building: Maintain existing building condition and operation throughout construction period. Repair damage caused by construction operations.

C. Condition of Existing Grounds: Maintain portions of existing grounds, landscaping, and hardscaping affected by construction operations throughout construction period. Repair damage caused by construction operations.

## 1.5 COORDINATION WITH OCCUPANTS

A. Full Owner Occupancy: Owner will occupy site and existing building(s) 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.

## 1.6 WORK RESTRICTIONS

A. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions:

1. Notify Owner not less than 14 days in advance of proposed service interruptions.
2. Obtain Owner's written permission before proceeding with service interruptions.
3. Outages to be limited to weekend, non-occupied hours as dictated by owner. Temporary power to be provided if Owner’s restrictions cannot be accommodated or if an outage is required of more than 4hrs.
4. Provide temporary power if unexpected conditions result in a service interruption in excess of the approved length.

B. Noise, Vibration, Dust, and Odors: Coordinate operations that may result in high levels of noise and vibration, dust, odors, or other disruption to Owner occupancy with Owner.

1. Notify Owner not less than 5 days in advance of proposed disruptive operations.
2. Obtain Owner's written permission before proceeding with disruptive operations.

C. Smoking and Controlled Substance Restrictions: Use of tobacco products, alcoholic beverages, and other controlled substances on Owner's property is not permitted.

D. Employee Identification: Owner will provide identification tags for Contractor personnel working on Project site. Require personnel to use identification tags at all times.

E. Employee Screening: Comply with Owner's requirements for drug and background screening of Contractor personnel prior to working on Project site.

1. Maintain list of approved screened personnel with Owner's representative.

## 1.7 SPECIFICATION AND DRAWING CONVENTIONS

A. 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. Imperative mood and streamlined language are generally used in the Specifications. 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.
2. Text Color: Text used in the Specifications, including units of measure, manufacturer and product names, and other text may appear in multiple colors or underlined as part of a hyperlink; no emphasis is implied by text with these characteristics.
3. Hypertext: Text used in the Specifications may contain hyperlinks. Hyperlinks may allow for access to linked information that is not residing in the Specifications. Unless otherwise indicated, linked information is not part of the Contract Documents.
4. Specification requirements are to be performed by Contractor unless specifically stated otherwise.

B. Division 00 Contracting Requirements: General provisions of the Contract, including General and Supplementary Conditions, apply to all Sections of the Specifications.

C. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.

# PART 2 - PRODUCTS (Not Used)

# PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

SECTION 012300 - ALTERNATES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for alternates.

1.2 DEFINITIONS

A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the bidding requirements that may be added to or deducted from the base bid amount if the Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.

1. Alternates described in this Section are part of the Work only if enumerated in the Agreement.
2. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternates into the Work. No other adjustments are made to the Contract Sum.

1.3 PROCEDURES

A. Coordination: Revise or adjust affected adjacent work as necessary to completely integrate work of the alternate into Project.

1. Include as part of each alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of alternate.

B. Execute accepted alternates under the same conditions as other work of the Contract.

C. Schedule: A schedule of alternates is included at the end of this Section. Specification Sections referenced in schedule contain requirements for materials necessary to achieve the work described under each alternate.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF ALTERNATES

A. Alternate 01, Additional Room Finishes.
   1. In rooms Test Room 108, Test Intake 109, Autoclave 110B, and Passageway 110C refinish rooms to include:
      a. Repair of damaged ceiling in Test Room 108.
      b. Re-finish and repaint walls and door frames.
      c. Replace flooring and wall base throughout.
      d. Replace lighting and lighting controls.

B. Alternate 02, Facility Exterior.
   1. Demolish the existing exterior greenhouse electrical panelboard.
   2. Repaint the entire building exterior.

C. Alternate 03, Environmental Growth Chambers.
   1. Repair the six (6) chilled water environmental growth chambers to include new chamber controls, pumps and stands, and connections to facility chilled water and steam systems.

D. Alternate 04, Maintenance 105 Door Relocation.
   1. Remove the existing flush solid-core wood door, frame, and hardware on the south wall and infil the opening. Create a new opening on the north wall and install door, hardware, and new metal frame. Finish both sides to match adjacent.

END OF SECTION 012300

SECTION 012500 - SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for substitutions.

B. Related Requirements:

1. Section 016000 "Product Requirements" for requirements for submitting comparable product submittals for products by listed manufacturers.

1.2 DEFINITIONS

A. Substitutions: Changes in products, materials, equipment, and methods of construction from those required by the Contract Documents and proposed by Contractor.

1. Substitutions for Cause: Changes proposed by Contractor that are required due to changed Project conditions, such as unavailability of product, regulatory changes, or unavailability of required warranty terms.
2. Substitutions for Convenience: Changes proposed by Contractor or Owner that are not required in order to meet other Project requirements but may offer advantage to Contractor or Owner.

1.3 ACTION SUBMITTALS

A. Substitution Requests: Submit three copies of each request for consideration. Identify product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.

1. Substitution Request Form: Use form acceptable to COR and Engineer.
2. Documentation: Show compliance with requirements for substitutions and the following, as applicable:

a. Statement indicating why specified product or fabrication or installation method cannot be provided, if applicable.
b. Coordination of information, including a list of changes or revisions needed to other parts of the Work and to construction performed by Owner and separate contractors that will be necessary to accommodate proposed substitution.
c. Detailed comparison of significant qualities of proposed substitutions with those of the Work specified. Include annotated copy of applicable Specification Section. Significant qualities may include attributes, such as performance, weight, size, durability, visual effect, sustainable design characteristics, warranties, and specific features and requirements indicated. Indicate deviations, if any, from the Work specified.
d. Product Data, including drawings and descriptions of products and fabrication and installation procedures.

e. Samples, where applicable or requested.
f. Certificates and qualification data, where applicable or requested.
g. List of similar installations for completed projects, with project names and addresses as well as names and addresses of Engineer and Owner.
h. Material test reports from a qualified testing agency, indicating and interpreting test results for compliance with requirements indicated.
i. Research reports evidencing compliance with building code in effect for Project, from ICC-ES.
j. Detailed comparison of Contractor's construction schedule using proposed substitutions with products specified for the Work, including effect on the overall Contract Time. If specified product or method of construction cannot be provided within the Contract Time, include letter from manufacturer, on manufacturer's letterhead, stating date of receipt of purchase order, lack of availability, or delays in delivery.
k. Cost information, including a proposal of change, if any, in the Contract Sum.
l. Contractor's certification that proposed substitution complies with requirements in the Contract Documents, except as indicated in substitution request, is compatible with related materials and is appropriate for applications indicated.
m. Contractor's waiver of rights to additional payment or time that may subsequently become necessary because of failure of proposed substitution to produce indicated results.

3. Engineer's Action: If necessary, Engineer will request additional information or documentation for evaluation within seven days of receipt of a request for substitution. Engineer will notify Contractor of acceptance or rejection of proposed substitution within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.

   a. Forms of Acceptance: Change Order, Construction Change Directive, or Engineer's Supplemental Instructions for minor changes in the Work.
   b. Use product specified if Engineer does not issue a decision on use of a proposed substitution within time allocated.

## 1.4 QUALITY ASSURANCE

A. Compatibility of Substitutions: Investigate and document compatibility of proposed substitution with related products and materials. Engage a qualified testing agency to perform compatibility tests recommended by manufacturers.

## 1.5 PROCEDURES

A. Coordination: Revise or adjust affected work as necessary to integrate work of the approved substitutions.

1.6 SUBSTITUTIONS

A. Substitutions for Cause: Submit requests for substitution immediately on discovery of need for change, but not later than 15 days prior to time required for preparation and review of related submittals.

1. Conditions: Engineer will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Engineer will return requests without action, except to record noncompliance with these requirements:

a. Requested substitution is consistent with the Contract Documents and will produce indicated results.
b. Substitution request is fully documented and properly submitted.
c. Requested substitution will not adversely affect Contractor's construction schedule.
d. Requested substitution has received necessary approvals of authorities having jurisdiction.
e. Requested substitution is compatible with other portions of the Work.
f. Requested substitution has been coordinated with other portions of the Work.
g. Requested substitution provides specified warranty.
h. If requested substitution involves more than one contractor, requested substitution has been coordinated with other portions of the Work, is uniform and consistent, is compatible with other products, and is acceptable to all contractors involved.

B. Substitutions for Convenience: Not allowed.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012500

SECTION 012600 - CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for handling and processing Contract modifications.

1.2 MINOR CHANGES IN THE WORK

A. The Contracting Officer's Representative (COR) will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or the Contract Time, on USDA Form.

1. Work Change Proposal Requests issued by the COR are not instructions either to stop work in progress or to execute the proposed change.

1.3 PROPOSAL REQUESTS

A. Owner-Initiated Proposal Requests: The COR will issue a detailed description of proposed changes in the Work that may require adjustment to the Contract Sum or the Contract Time. If necessary, the description will include supplemental or revised Drawings and Specifications.

1. Work Change Proposal Requests issued by the COR are not instructions either to stop work in progress or to execute the proposed change.

2. Within time specified in Proposal Request or 20 days, when not otherwise specified, after receipt of Proposal Request, submit a quotation estimating cost adjustments to the Contract Sum and the Contract Time necessary to execute the change.

a. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.
b. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
c. Include costs of labor and supervision directly attributable to the change.
d. Include an updated Contractor's construction schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.

B. Contractor-Initiated Proposals: If latent or changed conditions require modifications to the Contract, Contractor may initiate a claim by submitting a request for a change to the COR.

1. Include a statement outlining 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 the Contract Time.

2. Include a list of quantities of products required or eliminated and unit costs, with total amount of purchases and credits to be made. If requested, furnish survey data to substantiate quantities.
3. Indicate applicable taxes, delivery charges, equipment rental, and amounts of trade discounts.
4. Include costs of labor and supervision directly attributable to the change.
5. Include an updated Contractor's construction schedule that indicates the effect of the change, including, but not limited to, changes in activity duration, start and finish times, and activity relationship. Use available total float before requesting an extension of the Contract Time.
6. Comply with requirements in Section 012500 "Substitution Procedures" if the proposed change requires substitution of one product or system for product or system specified.

1.4 CHANGE ORDER PROCEDURES

A. On Owner's approval of a Work Change Proposal Request, the Contracting Officer will issue a Change Order for signatures of Owner and Contractor on USDA Form.

1.5 CONSTRUCTION CHANGE DIRECTIVE

A. Construction Change Directive: The COR may issue a Construction Change Directive on USDA Form. Construction Change Directive instructs Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order.

1. Construction Change Directive contains a complete description of change in the Work. It also designates method to be followed to determine change in the Contract Sum or the 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 change, submit an itemized account and supporting data necessary to substantiate cost and time adjustments to the Contract.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012600

SECTION 012900 - PAYMENT PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment. See Owner contract specifications for requirements.

1.2 SCHEDULE OF VALUES

A. Coordination: Coordinate preparation of the schedule of values with preparation of Contractor's construction schedule.

1. Coordinate line items in the schedule of values with items required to be indicated as separate activities in Contractor's construction schedule.

2. Submit the schedule of values to the COR and Engineer at earliest possible date, but no later than seven days before the date scheduled for submittal of initial Applications for Payment.

B. Format and Content: Use Project Manual table of contents as a guide to establish line items for the schedule of values. Provide at least one line item for each Specification Section.

1. Arrange schedule of values consistent with format of AIA Document G703 or form provided by owner.
2. Provide a breakdown of the Contract Sum in enough detail to facilitate continued evaluation of Applications for Payment and progress reports. Provide multiple line items for principal subcontract amounts in excess of five percent of the Contract Sum.

3. 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. Differentiate between items stored on-site and items stored off-site.

4. Allowances: Provide a separate line item in the schedule of values for each allowance. Show line-item value of unit-cost allowances, as a product of the unit cost, multiplied by measured quantity. Use information indicated in the Contract Documents to determine quantities.

5. Overhead Costs: Include total cost and proportionate share of general overhead and profit for each line item.

6. Overhead Costs: Show cost of temporary facilities and other major cost items that are not direct cost of actual work-in-place as separate line items.

7. Closeout Costs. Include separate line items under Contractor and principal subcontracts for Project closeout requirements in an amount totaling five percent of the Contract Sum and subcontract amount.

8. Schedule of Values Revisions: Revise the schedule of values when Change Orders or Construction Change Directives result in a change in the Contract Sum. Include at least one separate line item for each Change Order and Construction Change Directive.

1.3 APPLICATIONS FOR PAYMENT

A. See Owner contract requirements.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012900

SECTION 013100 - PROJECT MANAGEMENT AND COORDINATION

PART 1 - GENERAL

1.1 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. Related Requirements:

1. Section 017300 "Execution" for procedures for coordinating general installation and field-engineering services, including establishment of benchmarks and control points.

1.2 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.

1.3 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. Administrative Procedures: Coordinate scheduling and timing of required administrative procedures with other construction activities 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. Project closeout activities.
7. Startup and adjustment of systems.

C. Contractor Responsibility: The Contractor’s onsite superintendent or another designee of the Contractor shall be responsible for the performance and actions of their subcontractors while onsite, and shall be onsite at all times a subcontractor is onsite.

## 1.4 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 to the COR and Engineer in the form specified.

1. The COR will return without response those RFIs submitted to by other entities controlled by Contractor.
2. Coordinate and submit RFIs in a prompt manner 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. Owner name.
2. Owner's Project number.
3. Name of COR and Engineer.
4. Project number.
5. Date.
6. Name of Contractor.
7. RFI number, numbered sequentially.
8. RFI subject.
9. Specification Section number and title and related paragraphs, as appropriate.
10. Drawing number and detail references, as appropriate.
11. Field dimensions and conditions, as appropriate.
12. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
13. Contractor's signature.
14. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.

C. RFI Forms: AIA Document G716, or USDA Form to be provided, or software-generated form with substantially the same content as indicated above, acceptable to Engineer.

D. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow seven days for Engineer's response for each RFI. RFIs received by Engineer after 1:00 PST 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 Engineer's actions on submittals.
   g. Incomplete RFIs or inaccurately prepared RFIs.

2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt by Engineer of additional information.
3. Engineer'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 Engineer in writing within five 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. Use software log that is part of web-based Project management software. Include the following:

1. Project name.
2. Name and address of Contractor.
3. Name and address of Engineer.
4. RFI number including RFIs that were returned without action or withdrawn.
5. RFI description.
6. Date the RFI was submitted.
7. Date Engineer's response was received.

F. On receipt of Engineer's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Engineer within seven days if Contractor disagrees with response.

## 1.5 DIGITAL PROJECT MANAGEMENT PROCEDURES

A. Engineer's Data Files Not Available: Engineer will not provide Engineer's CAD drawing digital data files for Contractor's use during construction.

B. PDF Document Preparation: Where PDFs are required to be submitted to Engineer, 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.

## 1.6 PROJECT MEETINGS

A. General: Schedule and conduct meetings and conferences at Project site unless otherwise indicated.

B. Preconstruction Conference: Owner will schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Engineer, but no later than 15 days after execution of the Agreement.

1. Attendees: Authorized representatives of Owner, Engineer, 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. 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 and Engineer, 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: Contractor 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013100

SECTION 013300 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Submittal schedule requirements.
2. Administrative and procedural requirements for submittals.

1.2 DEFINITIONS

A. Action Submittals: Written and graphic information and physical samples that require Engineer's responsive action. Action submittals are those submittals indicated in individual Specification Sections as "action submittals."

B. Informational Submittals: Written and graphic information and physical samples that do not require Engineer's responsive action. Submittals may be rejected for not complying with requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

1.3 SUBMITTAL SCHEDULE

A. Submittal Schedule: Submit, as an action submittal, a list of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and additional time for handling and reviewing submittals required by those corrections.

1.4 SUBMITTAL FORMATS

A. Submittal Information: Include the following information in each submittal:

1. Project name.
2. Date.
3. Name of Engineer.
4. Name of Construction Manager.
5. Name of Contractor.
6. Name of firm or entity that prepared submittal.
7. Names of subcontractor, manufacturer, and supplier.
8. Unique submittal number, including revision identifier. Include Specification Section number with sequential alphanumeric identifier; and alphanumeric suffix for resubmittals.
9. Category and type of submittal.
10. Submittal purpose and description.

11. Number and title of Specification Section, with paragraph number and generic name for each of multiple items.
12. Drawing number and detail references, as appropriate.
13. Indication of full or partial submittal.
14. Location(s) where product is to be installed, as appropriate.
15. Other necessary identification.
16. Remarks.
17. Signature of transmitter.

B. Options: Identify options requiring selection by Engineer.

C. Deviations and Additional Information: On each submittal, clearly indicate deviations from requirements in the Contract Documents, including minor variations and limitations; include relevant additional information and revisions, other than those requested by Engineer on previous submittals. Indicate by highlighting on each submittal or noting on attached separate sheet.

D. Electronic Submittals: Prepare submittals as PDF package, incorporating complete information into each PDF file. Name PDF file with submittal number.

E. Submittals for Utilizing Web-Based Project Management Software: Prepare submittals as PDF files, or other format indicated by Project management software.

## 1.5 SUBMITTAL PROCEDURES

A. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.

1. Email: Prepare submittals as PDF package, and transmit to Engineer by sending via email. Include PDF transmittal form. Include information in email subject line as requested by Engineer.
2. Web-Based Project Management Software: Prepare submittals in PDF form, and upload to web-based Project management software website. Enter required data in web-based software site to fully identify submittal.
3. Paper: Prepare submittals in paper form, and deliver to Engineer.

B. 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. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.
3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.

C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineer's 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. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
2. Resubmittal Review: Allow 15 days for review of each resubmittal.

D. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.

E. 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.

F. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's action stamp.

## 1.6 SUBMITTAL REQUIREMENTS

A. 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 published data are unsuitable 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 catalog cuts.
    b. Manufacturer's product specifications.
    c. Standard color charts.
    d. Statement of compliance with specified referenced standards.
    e. Testing by recognized testing agency.
    f. Application of testing agency labels and seals.
    g. Notation of coordination requirements.
    h. Availability and delivery time information.

4. For equipment, include the following in addition to the above, as applicable:

    a. Wiring diagrams that show factory-installed wiring.
    b. Printed performance curves.
    c. Operational range diagrams.
    d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.

5. Submit Product Data before Shop Drawings, and before or concurrent with Samples.

B. 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 unless submittal based on Engineer's digital data drawing files is otherwise permitted.

1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:

   a. Identification of products.
   b. Schedules.
   c. Compliance with specified standards.
   d. Notation of coordination requirements.
   e. Notation of dimensions established by field measurement.
   f. Relationship and attachment to adjoining construction clearly indicated.
   g. Seal and signature of professional engineer if specified.

C. Samples: Submit Samples for review of kind, color, pattern, and texture for a check of these characteristics with other materials.

1. Transmit Samples that contain multiple, related components such as accessories together in one submittal package. Send samples to:

   Mr. Dan Flores,
   Building 6414
   22675 North Moorefield Rd.
   Edinburg, Tx., 78542

2. Identification: Permanently attach label on unexposed side of Samples that includes the following:

   a. Project name and submittal number.
   b. Generic description of Sample.
   c. Product name and name of manufacturer.
   d. Sample source.
   e. Number and title of applicable Specification Section.
   f. Specification paragraph number and generic name of each item.

3. Email Transmittal: Provide PDF transmittal. Include digital image file illustrating Sample characteristics, and identification information for record.
4. Web-Based Project Management Software: Prepare submittals in PDF form, and upload to web-based Project software website. Enter required data in web-based software site to fully identify submittal.
5. Paper Transmittal: Include paper transmittal including complete submittal information indicated.
6. Disposition: Maintain sets of approved Samples at Project site, available for quality-control comparisons throughout the course of construction activity. Sample sets may be used to determine final acceptance of construction associated with each set.

   a. Samples that may be incorporated into the Work are indicated in individual Specification Sections. Such Samples must be in an undamaged condition at time of use.

b. Samples not incorporated into the Work, or otherwise designated as Owner's property, are the property of Contractor.

7. Samples for Initial Selection: Submit manufacturer's color charts consisting of units or sections of units showing the full range of colors, textures, and patterns available.

a. Number of Samples: Submit one full set(s) of available choices where color, pattern, texture, or similar characteristics are required to be selected from manufacturer's product line. Engineer will return submittal with options selected.

8. Samples for Verification: Submit full-size units or Samples of size indicated, prepared from same material to be used for the Work, cured and finished in manner specified, and physically identical with material or product proposed for use, and that show full range of color and texture variations expected. Samples include, but are not limited to, the following: partial sections of manufactured or fabricated components; small cuts or containers of materials; complete units of repetitively used materials; swatches showing color, texture, and pattern; color range sets; and components used for independent testing and inspection.

a. Number of Samples: Submit three sets of Samples. Engineer will retain two Sample sets; remainder will be returned. Mark up and retain one returned Sample set as a project record Sample.

1) Submit a single Sample where assembly details, workmanship, fabrication techniques, connections, operation, and other similar characteristics are to be demonstrated.
2) If variation in color, pattern, texture, or other characteristic is inherent in material or product represented by a Sample, submit at least three sets of paired units that show approximate limits of variations.

D. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:

E. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.

F. Design Data: Prepare and submit written and graphic information indicating compliance with indicated performance and design criteria in individual Specification Sections. Include list of assumptions and summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Number each page of submittal.

G. Certificates:

1. Certificates and Certifications Submittals: Submit a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity. Provide a notarized signature where indicated.

2. Installer Certificates: Submit written statements on manufacturer's letterhead certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.
3. Manufacturer Certificates: Submit written statements on manufacturer's letterhead certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.
4. Material Certificates: Submit written statements on manufacturer's letterhead certifying that material complies with requirements in the Contract Documents.
5. Product Certificates: Submit written statements on manufacturer's letterhead certifying that product complies with requirements in the Contract Documents.
6. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of Welding Procedure Specification and Procedure Qualification Record on AWS forms. Include names of firms and personnel certified.

H. Test and Research Reports:

1. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for substrate preparation and primers required.
2. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.
3. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.
4. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.
5. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.
6. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:

    a. Name of evaluation organization.
    b. Date of evaluation.
    c. Time period when report is in effect.
    d. Product and manufacturers' names.
    e. Description of product.
    f. Test procedures and results.
    g. Limitations of use.

## 1.7 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are insufficient to perform services or certification required, submit a written request for additional information to Engineer.

B. Delegated-Design Services Certification: In addition to Shop Drawings, Product Data, and other required submittals, submit digitally signed PDF file of certificate, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional.

1. Indicate that products and systems comply with performance and design criteria in the Contract Documents. Include list of codes, loads, and other factors used in performing these services.

## 1.8 CONTRACTOR'S REVIEW

A. Action Submittals and Informational Submittals: 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. Contractor's Approval: Indicate Contractor's approval for each submittal with a uniform approval stamp. Include name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.

1. Engineer will not review submittals received from Contractor that do not have Contractor's review and approval.

## 1.9 ENGINEER'S REVIEW

A. Action Submittals: Engineer will review each submittal, indicate corrections or revisions required, and return it.

1. PDF Submittals: Engineer will indicate, via markup on each submittal, the appropriate action.

2. Submittals by Web-Based Project Management Software: Engineer will indicate, on Project management software website, the appropriate action.

B. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements. Engineer will forward each submittal to appropriate party.

C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Engineer.

D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

E. Engineer will discard submittals received from sources other than Contractor.

F. Submittals not required by the Contract Documents will be returned by Engineer without action.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013300

SECTION 014000 - QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for quality assurance and quality control.

B. Testing and inspection 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. Specified tests, inspections, and related actions do not limit Contractor's other quality-assurance and quality-control procedures that facilitate compliance with the Contract Document requirements.
2. Requirements for Contractor to provide quality-assurance and quality-control services required by Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.

1.2 DEFINITIONS

A. Experienced: When used with an entity or individual, "experienced" unless otherwise further described means having successfully completed a minimum of five previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

B. Field Quality-Control Tests and Inspections: Tests and inspections that are performed on-site for installation of the Work and for completed Work.

C. 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, assembly, and similar operations.

1. Use of trade-specific terminology in referring to a Work result does not require that certain construction activities specified apply exclusively to specific trade(s).

D. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria. Unless otherwise indicated, copies of reports of tests or inspections performed for other than the Project do not meet this definition.

E. Product Tests: Tests and inspections that are performed by a nationally recognized testing laboratory (NRTL) according to 29 CFR 1910.7, by a testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program (NVLAP), or by a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.

F. Source Quality-Control Tests and Inspections: Tests and inspections that are performed at the source; for example, plant, mill, factory, or shop.

G. Testing Agency: An entity engaged to perform specific tests, inspections, or both. Testing laboratory shall have the same meaning as testing agency.

H. 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.

I. 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. Contractor's quality-control services do not include contract administration activities performed by Engineer.

## 1.3 DELEGATED-DESIGN SERVICES

A. Performance and Design Criteria: Where professional design services or certifications by a design professional are specifically required of Contractor by the Contract Documents, provide products and systems complying with specific performance and design criteria indicated.

1. If criteria indicated are not sufficient to perform services or certification required, submit a written request for additional information to Engineer.

B. Delegated-Design Services Statement: Submit a statement, signed and sealed by the responsible design professional, for each product and system specifically assigned to Contractor to be designed or certified by a design professional, indicating that the products and systems are in compliance with performance and design criteria indicated. Include list of codes, loads, and other factors used in performing these services.

## 1.4 CONFLICTING REQUIREMENTS

A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements is specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, inform the Engineer regarding the conflict and obtain clarification prior to proceeding with the Work. Refer conflicting requirements that are different, but apparently equal, to Engineer for clarification 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 Engineer for a decision before proceeding.

## 1.5 INFORMATIONAL SUBMITTALS

A. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility submitted to authorities having jurisdiction before starting work on the following systems:

1. Seismic-force-resisting system, designated seismic system, or component listed in the Statement of Special Inspections.
2. Main wind-force-resisting system or a wind-resisting component listed in the Statement of Special Inspections.

B. Testing Agency Qualifications: For testing agencies specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include proof of qualifications in the form of a recent report on the inspection of the testing agency by a recognized authority.

C. Permits, Licenses, and Certificates: For Owner's record, 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 REPORTS AND DOCUMENTS

A. Test and Inspection Reports: Prepare and submit certified written reports specified in other Sections. Include the following:

1. Date of issue.
2. Project title and number.
3. Name, address, telephone number, and email address 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 inspection.
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.

B. Manufacturer's Technical Representative's Field Reports: Prepare written information documenting manufacturer's technical representative's tests and inspections specified in other Sections. Include the following:

1. Statement on condition of substrates and their acceptability for installation of product.
2. Statement that products at Project site comply with requirements.
3. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.

4. Results of operational and other tests and a statement of whether observed performance complies with requirements.
5. Other required items indicated in individual Specification Sections.

C. Factory-Authorized Service Representative's Reports: Prepare written information documenting manufacturer's factory-authorized service representative's tests and inspections specified in other Sections. Include the following:

1. Statement that equipment complies with requirements.
2. Results of operational and other tests and a statement of whether observed performance complies with requirements.
3. Other required items indicated in individual Specification Sections.

## 1.7 QUALITY ASSURANCE

A. Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.

B. 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. As applicable, procure products from manufacturers able to meet qualification requirements, warranty requirements, and technical or factory-authorized service representative requirements.

C. 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.

D. Installer Qualifications: A firm or individual experienced in installing, erecting, applying, 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.

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 in material, design, and extent to those indicated for this Project.

F. Specialists: Certain Specification Sections 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. Requirements of authorities having jurisdiction shall supersede requirements for specialists.

G. Testing and Inspecting Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspection indicated, as documented according to ASTM E329; and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.

H. Manufacturer's Technical Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to observe and 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. Build laboratory mockups at testing facility using personnel, products, and methods of construction indicated for the completed Work.
d. When testing is complete, remove test specimens and test assemblies; do not reuse products on Project.

2. Testing Agency Responsibilities: Submit a certified written report of each test, inspection, and similar quality-assurance service to Engineer and Commissioning Authority, with copy to Contractor. Interpret tests and inspections and state in each report whether tested and inspected work complies with or deviates from the Contract Documents.

## 1.8 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 inspection they are engaged to perform.
2. 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.

B. Contractor Responsibilities: Tests and inspections not explicitly assigned to Owner are Contractor's responsibility. Perform additional quality-control activities, whether specified or not, to verify and document that the Work complies with requirements.

1. Engage a qualified testing agency to perform quality-control services.

a. Contractor shall not employ same entity engaged by Owner, unless agreed to in writing by Owner.

2. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspection will be performed.
3. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.

4. Testing and inspection requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
5. Submit additional copies of each written report directly to authorities having jurisdiction, when they so direct.

C. 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.

D. Testing Agency Responsibilities: Cooperate with Engineer, Commissioning Authority and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.

1. Notify Engineer, Commissioning Authority, and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.
2. Determine the locations 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 duties of Contractor.

E. 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 Section 013300 "Submittal Procedures."

F. Manufacturer's Technical Services: Where indicated, engage a manufacturer's technical representative to observe and inspect the Work. Manufacturer's technical representative's services include participation in preinstallation conferences, examination of substrates and conditions, verification of materials, observation of Installer activities, inspection of completed portions of the Work, and submittal of written reports.

G. Contractor's Associated Requirements and Services: Cooperate with agencies and representatives 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 inspection. Assist agency in obtaining samples.
4. Facilities for storage and field curing of test samples.
5. Preliminary design mix proposed for use for material mixes that require control by testing agency.
6. Security and protection for samples and for testing and inspection equipment at Project site.

H. Coordination: Coordinate sequence of activities to accommodate required quality-assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspection.

1. Schedule times for tests, inspections, obtaining samples, and similar activities.

## 1.9 SPECIAL TESTS AND INSPECTIONS

A. Special Tests and Inspections: Owner will engage a qualified testing agency to conduct special tests and inspections required by authorities having jurisdiction as the responsibility of Owner, and as follows:

1. Verifying that manufacturer maintains detailed fabrication and quality-control procedures and reviewing the completeness and adequacy of those procedures to perform the Work.
2. Notifying Engineer, Commissioning Authority, and Contractor promptly of irregularities and deficiencies observed in the Work during performance of its services.
3. Submitting a certified written report of each test, inspection, and similar quality-control service to Engineer and Commissioning Authority with copy to Contractor and to authorities having jurisdiction.
4. Submitting a final report of special tests and inspections at Substantial Completion, which includes a list of unresolved deficiencies.
5. Interpreting tests and inspections and stating in each report whether tested and inspected work complies with or deviates from the Contract Documents.
6. Retesting and re-inspecting corrected Work.

# PART 2 - PRODUCTS (Not Used)

# PART 3 - EXECUTION

## 3.1 TEST AND INSPECTION LOG

A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:

1. Date test or inspection was conducted.
2. Description of the Work tested or inspected.
3. Date test or inspection results were transmitted to Engineer.
4. Identification of testing agency or special inspector conducting test or inspection.

B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Engineer's, Commissioning Authority's, and authorities' having jurisdiction reference during normal working hours.

1. Submit log at Project closeout as part of Project Record Documents.

3.2 REPAIR AND PROTECTION

A. General: On completion of testing, inspection, 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 or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 017300 "Execution."

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 014000

SECTION 014200 - REFERENCES

PART 1 - GENERAL

1.1 DEFINITIONS

A. General: Basic Contract definitions are included in the Conditions of the Contract.

B. "Approved": When used to convey Architect's action on Contractor's submittals, applications, and requests, "approved" is limited to Architect's duties and responsibilities as stated in the Conditions of the Contract.

C. "Directed": A command or instruction by Architect. Other terms including "requested," "authorized," "selected," "required," and "permitted" have the same meaning as "directed."

D. "Indicated": Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including "shown," "noted," "scheduled," and "specified" have the same meaning as "indicated."

E. "Regulations": Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.

F. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

G. "Install": Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.

H. "Provide": Furnish and install, complete and ready for the intended use.

I. "Project Site": Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.

1.2 INDUSTRY STANDARDS

A. Applicability of Standards: Unless the Contract Documents include more stringent requirements, applicable construction industry standards have the same force and effect as if bound or copied directly into the Contract Documents to the extent referenced. Such standards are made a part of the Contract Documents by reference.

B. Publication Dates: Comply with standards in effect as of date of the Contract Documents unless otherwise indicated.

1. For standards referenced by applicable building codes, comply with dates of standards as listed in building codes.

C. Copies of Standards: Each entity engaged in construction on Project should be familiar with industry standards applicable to its construction activity. Copies of applicable standards are not bound with the Contract Documents.

1. Where copies of standards are needed to perform a required construction activity, obtain copies directly from publication source.

## 1.3 ABBREVIATIONS AND ACRONYMS

A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities indicated in Gale's "Encyclopedia of Associations: National Organizations of the U.S." or in Columbia Books' "National Trade & Professional Associations of the United States."

B. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Abbreviations and acronyms not included in this list shall mean the recognized name of the entities indicated in Gale's "Encyclopedia of Associations: National Organizations of the U.S." or in Columbia Books' "National Trade & Professional Associations of the United States." The information in this list is subject to change and is believed to be accurate as of the date of the Contract Documents.

1. AABC - Associated Air Balance Council; www.aabc.com.
2. AAMA - American Architectural Manufacturers Association; www.aamanet.org.
3. AAPFCO - Association of American Plant Food Control Officials; www.aapfco.org.
4. AASHTO - American Association of State Highway and Transportation Officials; www.transportation.org.
5. AATCC - American Association of Textile Chemists and Colorists; www.aatcc.org.
6. ABMA - American Bearing Manufacturers Association; www.americanbearings.org.
7. ABMA - American Boiler Manufacturers Association; www.abma.com.
8. ACI - American Concrete Institute; (Formerly: ACI International); www.concrete.org.
9. ACPA - American Concrete Pipe Association; www.concrete-pipe.org.
10. AEIC - Association of Edison Illuminating Companies, Inc. (The); www.aeic.org.
11. AF&PA - American Forest & Paper Association; www.afandpa.org.
12. AGA - American Gas Association; www.aga.org.
13. AHAM - Association of Home Appliance Manufacturers; www.aham.org.
14. AHRI - Air-Conditioning, Heating, and Refrigeration Institute (The); www.ahrinet.org.
15. AI - Asphalt Institute; www.asphaltinstitute.org.
16. AIA - American Institute of Architects (The); www.aia.org.
17. AISC - American Institute of Steel Construction; www.aisc.org.
18. AISI - American Iron and Steel Institute; www.steel.org.
19. AITC - American Institute of Timber Construction; www.aitc-glulam.org.
20. AMCA - Air Movement and Control Association International, Inc.; www.amca.org.
21. ANSI - American National Standards Institute; www.ansi.org.
22. AOSA - Association of Official Seed Analysts, Inc.; www.aosaseed.com.
23. APA - APA - The Engineered Wood Association; www.apawood.org.
24. APA - Architectural Precast Association; www.archprecast.org.
25. API - American Petroleum Institute; www.api.org.
26. ARI - Air-Conditioning & Refrigeration Institute; (See AHRI).
27. ARI - American Refrigeration Institute; (See AHRI).

28. ARMA - Asphalt Roofing Manufacturers Association; www.asphaltroofing.org.
29. ASCE - American Society of Civil Engineers; www.asce.org.
30. ASCE/SEI - American Society of Civil Engineers/Structural Engineering Institute; (See ASCE).
31. ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers; www.ashrae.org.
32. ASME - ASME International; (American Society of Mechanical Engineers); www.asme.org.
33. ASSE - American Society of Sanitary Engineering; www.asse-plumbing.org.
34. ASSP - American Society of Safety Professionals (The); www.assp.org.
35. ASTM - ASTM International; www.astm.org.
36. ATIS - Alliance for Telecommunications Industry Solutions; www.atis.org.
37. AVIXA - Audiovisual and Integrated Experience Association; (Formerly: Infocomm International); www.soundandcommunications.com.
38. AWEA - American Wind Energy Association; www.awea.org.
39. AWI - Architectural Woodwork Institute; www.awinet.org.
40. AWMAC - Architectural Woodwork Manufacturers Association of Canada; www.awmac.com.
41. AWPA - American Wood Protection Association; www.awpa.com.
42. AWS - American Welding Society; www.aws.org.
43. AWWA - American Water Works Association; www.awwa.org.
44. BHMA - Builders Hardware Manufacturers Association; www.buildershardware.com.
45. BIA - Brick Industry Association (The); www.gobrick.com.
46. BICSI - BICSI, Inc.; www.bicsi.org.
47. BIFMA - BIFMA International; (Business and Institutional Furniture Manufacturer's Association); www.bifma.org.
48. BISSC - Baking Industry Sanitation Standards Committee; www.bissc.org.
49. BWF - Badminton World Federation; (Formerly: International Badminton Federation); www.bissc.org.
50. CDA - Copper Development Association; www.copper.org.
51. CE - Conformite Europeenne; http://ec.europa.eu/growth/single-market/ce-marking/.
52. CEA - Canadian Electricity Association; www.electricity.ca.
53. CFFA - Chemical Fabrics and Film Association, Inc.; www.chemicalfabricsandfilm.com.
54. CFSEI - Cold-Formed Steel Engineers Institute; www.cfsei.org.
55. CGA - Compressed Gas Association; www.cganet.com.
56. CIMA - Cellulose Insulation Manufacturers Association; www.cellulose.org.
57. CISCA - Ceilings & Interior Systems Construction Association; www.cisca.org.
58. CISPI - Cast Iron Soil Pipe Institute; www.cispi.org.
59. CLFMI - Chain Link Fence Manufacturers Institute; www.chainlinkinfo.org.
60. CPA - Composite Panel Association; www.compositepanel.org.
61. CRI - Carpet and Rug Institute (The); www.carpet-rug.org.
62. CRRC - Cool Roof Rating Council; www.coolroofs.org.
63. CRSI - Concrete Reinforcing Steel Institute; www.crsi.org.
64. CSA - CSA Group; www.csa-group.org.
65. CSI - Construction Specifications Institute (The); www.csiresources.org.
66. CSSB - Cedar Shake & Shingle Bureau; www.cedarbureau.org.
67. CTA - Consumer Technology Association; www.cta.tech.
68. CTI - Cooling Technology Institute; (Formerly: Cooling Tower Institute); www.coolingtechnology.org.
69. CWC - Composite Wood Council; (See CPA).
70. DASMA - Door and Access Systems Manufacturers Association; www.dasma.com.

71. DHA - Decorative Hardwoods Association; (Formerly: Hardwood Plywood & Veneer Association); www.decorativehardwoods.org.
72. DHI - Door and Hardware Institute; www.dhi.org.
73. ECA - Electronic Components Association; (See ECIA).
74. ECAMA - Electronic Components Assemblies & Materials Association; (See ECIA).
75. ECIA - Electronic Components Industry Association; www.eciaonline.org.
76. EIA - Electronic Industries Alliance; (See TIA).
77. EIMA - EIFS Industry Members Association; www.eima.com.
78. EJMA - Expansion Joint Manufacturers Association, Inc.; www.ejma.org.
79. EOS/ESD Association; (Electrostatic Discharge Association); www.esda.org.
80. ESTA - Entertainment Services and Technology Association; (See PLASA).
81. ETL - Intertek (See Intertek); www.intertek.com.
82. EVO - Efficiency Valuation Organization; www.evo-world.org.
83. FCI - Fluid Controls Institute; www.fluidcontrolsinstitute.org.
84. FIBA - Federation Internationale de Basketball; (The International Basketball Federation); www.fiba.com.
85. FIVB - Federation Internationale de Volleyball; (The International Volleyball Federation); www.fivb.org.
86. FM Approvals - FM Approvals LLC; www.fmglobal.com.
87. FM Global - FM Global; (Formerly: FMG - FM Global); www.fmglobal.com.
88. FRSA - Florida Roofing, Sheet Metal Contractors Association, Inc.; www.floridaroof.com.
89. FSA - Fluid Sealing Association; www.fluidsealing.com.
90. FSC - Forest Stewardship Council U.S.; www.fscus.org.
91. GA - Gypsum Association; www.gypsum.org.
92. GANA - Glass Association of North America; (See NGA).
93. GS - Green Seal; www.greenseal.org.
94. HI - Hydraulic Institute; www.pumps.org.
95. HI/GAMA - Hydronics Institute/Gas Appliance Manufacturers Association; (See AHRI).
96. HMMA - Hollow Metal Manufacturers Association; (See NAAMM).
97. HPVA - Hardwood Plywood & Veneer Association; (See DHA).
98. HPW - H. P. White Laboratory, Inc.; www.hpwhite.com.
99. IAPSC - International Association of Professional Security Consultants; www.iapsc.org.
100. IAS - International Accreditation Service; www.iasonline.org.
101. ICBO - International Conference of Building Officials; (See ICC).
102. ICC - International Code Council; www.iccsafe.org.
103. ICEA - Insulated Cable Engineers Association, Inc.; www.icea.net.
104. ICPA - International Cast Polymer Alliance; www.icpa-hq.org.
105. ICRI - International Concrete Repair Institute, Inc.; www.icri.org.
106. IEC - International Electrotechnical Commission; www.iec.ch.
107. IEEE - Institute of Electrical and Electronics Engineers, Inc. (The); www.ieee.org.
108. IES - Illuminating Engineering Society; (Formerly: Illuminating Engineering Society of North America); www.ies.org.
109. IESNA - Illuminating Engineering Society of North America; (See IES).
110. IEST - Institute of Environmental Sciences and Technology; www.iest.org.
111. IGMA - Insulating Glass Manufacturers Alliance; www.igmaonline.org.
112. IGSHPA - International Ground Source Heat Pump Association; www.igshpa.org.
113. II - Infocomm International; (See AVIXA).
114. ILI - Indiana Limestone Institute of America, Inc.; www.iliai.com.
115. Intertek - Intertek Group; (Formerly: ETL SEMCO; Intertek Testing Service NA); www.intertek.com.

116. ISA - International Society of Automation (The); (Formerly: Instrumentation, Systems, and Automation Society); www.isa.org.
117. ISAS - Instrumentation, Systems, and Automation Society (The); (See ISA).
118. ISFA - International Surface Fabricators Association; (Formerly: International Solid Surface Fabricators Association); www.isfanow.org.
119. ISO - International Organization for Standardization; www.iso.org.
120. ISSFA - International Solid Surface Fabricators Association; (See ISFA).
121. ITU - International Telecommunication Union; www.itu.int/home.
122. KCMA - Kitchen Cabinet Manufacturers Association; www.kcma.org.
123. LMA - Laminating Materials Association; (See CPA).
124. LPI - Lightning Protection Institute; www.lightning.org.
125. MBMA - Metal Building Manufacturers Association; www.mbma.com.
126. MCA - Metal Construction Association; www.metalconstruction.org.
127. MFMA - Maple Flooring Manufacturers Association, Inc.; www.maplefloor.org.
128. MFMA - Metal Framing Manufacturers Association, Inc.; www.metalframingmfg.org.
129. MHIA - Material Handling Industry of America; www.mhia.org.
130. MIA - Marble Institute of America; (See NSI).
131. MMPA - Moulding & Millwork Producers Association; www.wmmpa.com.
132. MPI - Master Painters Institute; www.paintinfo.com.
133. MSS - Manufacturers Standardization Society of The Valve and Fittings Industry Inc.; www.mss-hq.org.
134. NAAMM - National Association of Architectural Metal Manufacturers; www.naamm.org.
135. NACE - NACE International; (National Association of Corrosion Engineers International); www.nace.org.
136. NADCA - National Air Duct Cleaners Association; www.nadca.com.
137. NAIMA - North American Insulation Manufacturers Association; www.naima.org.
138. NALP - National Association of Landscape Professionals; www.landscapeprofessionals.org.
139. NBGQA - National Building Granite Quarries Association, Inc.; www.nbgqa.com.
140. NBI - New Buildings Institute; www.newbuildings.org.
141. NCAA - National Collegiate Athletic Association (The); www.ncaa.org.
142. NCMA - National Concrete Masonry Association; www.ncma.org.
143. NEBB - National Environmental Balancing Bureau; www.nebb.org.
144. NECA - National Electrical Contractors Association; www.necanet.org.
145. NeLMA - Northeastern Lumber Manufacturers Association; www.nelma.org.
146. NEMA - National Electrical Manufacturers Association; www.nema.org.
147. NETA - InterNational Electrical Testing Association; www.netaworld.org.
148. NFHS - National Federation of State High School Associations; www.nfhs.org.
149. NFPA - National Fire Protection Association; www.nfpa.org.
150. NFPA - NFPA International; (See NFPA).
151. NFRC - National Fenestration Rating Council; www.nfrc.org.
152. NGA - National Glass Association (The); (Formerly: Glass Association of North America); www.glass.org.
153. NHLA - National Hardwood Lumber Association; www.nhla.com.
154. NLGA - National Lumber Grades Authority; www.nlga.org.
155. NOFMA - National Oak Flooring Manufacturers Association; (See NWFA).
156. NOMMA - National Ornamental & Miscellaneous Metals Association; www.nomma.org.
157. NRCA - National Roofing Contractors Association; www.nrca.net.
158. NRMCA - National Ready Mixed Concrete Association; www.nrmca.org.
159. NSF - NSF International; www.nsf.org.

160. NSI - National Stone Institute; (Formerly: Marble Institute of America); www.naturalstoneinstitute.org.
161. NSPE - National Society of Professional Engineers; www.nspe.org.
162. NSSGA - National Stone, Sand & Gravel Association; www.nssga.org.
163. NTMA - National Terrazzo & Mosaic Association, Inc. (The); www.ntma.com.
164. NWFA - National Wood Flooring Association; www.nwfa.org.
165. PCI - Precast/Prestressed Concrete Institute; www.pci.org.
166. PDI - Plumbing & Drainage Institute; www.pdionline.org.
167. PLASA - PLASA; (Formerly: ESTA - Entertainment Services and Technology Association); www.plasa.org.
168. RCSC - Research Council on Structural Connections; www.boltcouncil.org.
169. RFCI - Resilient Floor Covering Institute; www.rfci.com.
170. RIS - Redwood Inspection Service; www.redwoodinspection.com.
171. SAE - SAE International; www.sae.org.
172. SCTE - Society of Cable Telecommunications Engineers; www.scte.org.
173. SDI - Steel Deck Institute; www.sdi.org.
174. SDI - Steel Door Institute; www.steeldoor.org.
175. SEFA - Scientific Equipment and Furniture Association (The); www.sefalabs.com.
176. SEI/ASCE - Structural Engineering Institute/American Society of Civil Engineers; (See ASCE).
177. SIA - Security Industry Association; www.siaonline.org.
178. SJI - Steel Joist Institute; www.steeljoist.org.
179. SMA - Screen Manufacturers Association; www.smainfo.org.
180. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association; www.smacna.org.
181. SMPTE - Society of Motion Picture and Television Engineers; www.smpte.org.
182. SPFA - Spray Polyurethane Foam Alliance; www.sprayfoam.org.
183. SPIB - Southern Pine Inspection Bureau; www.spib.org.
184. SPRI - Single Ply Roofing Industry; www.spri.org.
185. SRCC - Solar Rating & Certification Corporation; www.solar-rating.org.
186. SSINA - Specialty Steel Industry of North America; www.ssina.com.
187. SSPC - SSPC: The Society for Protective Coatings; www.sspc.org.
188. STI - Steel Tank Institute; www.steeltank.com.
189. SWI - Steel Window Institute; www.steelwindows.com.
190. SWPA - Submersible Wastewater Pump Association; www.swpa.org.
191. TCA - Tilt-Up Concrete Association; www.tilt-up.org.
192. TCNA - Tile Council of North America, Inc.; www.tileusa.com.
193. TEMA - Tubular Exchanger Manufacturers Association, Inc.; www.tema.org.
194. TIA - Telecommunications Industry Association (The); (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance); www.tiaonline.org.
195. TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance; (See TIA).
196. TMS - The Masonry Society; www.masonrysociety.org.
197. TPI - Truss Plate Institute; www.tpinst.org.
198. TPI - Turfgrass Producers International; www.turfgrasssod.org.
199. TRI - Tile Roofing Institute; www.tileroofing.org.
200. UL - Underwriters Laboratories Inc.; www.ul.com.
201. UNI - Uni-Bell PVC Pipe Association; www.uni-bell.org.
202. USAV - USA Volleyball; www.usavolleyball.org.
203. USGBC - U.S. Green Building Council; www.usgbc.org.

204. USITT - United States Institute for Theatre Technology, Inc.; www.usitt.org.
205. WA - Wallcoverings Association; www.wallcoverings.org.
206. WASTEC - Waste Equipment Technology Association; www.wastec.org.
207. WCLIB - West Coast Lumber Inspection Bureau; www.wclib.org.
208. WCMA - Window Covering Manufacturers Association; www.wcmanet.org.
209. WDMA - Window & Door Manufacturers Association; www.wdma.com.
210. WI - Woodwork Institute; www.wicnet.org.
211. WSRCA - Western States Roofing Contractors Association; www.wsrca.com.
212. WWPA - Western Wood Products Association; www.wwpa.org.

C. Federal Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. Information is subject to change and is up to date as of the date of the Contract Documents.

1. COE - Army Corps of Engineers; www.usace.army.mil.
2. CPSC - Consumer Product Safety Commission; www.cpsc.gov.
3. DOC - Department of Commerce; National Institute of Standards and Technology; www.nist.gov.
4. DOD - Department of Defense; www.quicksearch.dla.mil.
5. DOE - Department of Energy; www.energy.gov.
6. EPA - Environmental Protection Agency; www.epa.gov.
7. FAA - Federal Aviation Administration; www.faa.gov.
8. FG - Federal Government Publications; www.gpo.gov/fdsys.
9. GSA - General Services Administration; www.gsa.gov.
10. HUD - Department of Housing and Urban Development; www.hud.gov.
11. LBL - Lawrence Berkeley National Laboratory; Environmental Energy Technologies Division; www.eetd.lbl.gov.
12. OSHA - Occupational Safety & Health Administration; www.osha.gov.
13. SD - Department of State; www.state.gov.
14. TRB - Transportation Research Board; National Cooperative Highway Research Program; The National Academies; www.trb.org.
15. USDA - Department of Agriculture; Agriculture Research Service; U.S. Salinity Laboratory; www.ars.usda.gov.
16. USDA - Department of Agriculture; Rural Utilities Service; www.usda.gov.
17. USDOJ - Department of Justice; Office of Justice Programs; National Institute of Justice; www.ojp.usdoj.gov.
18. USP - U.S. Pharmacopeial Convention; www.usp.org.
19. USPS - United States Postal Service; www.usps.com.

D. Standards and Regulations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the standards and regulations in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.

1. CFR - Code of Federal Regulations; Available from Government Printing Office; www.govinfo.gov.
2. DOD - Department of Defense; Military Specifications and Standards; Available from DLA Document Services; www.quicksearch.dla.mil.
3. DSCC - Defense Supply Center Columbus; (See FS).
4. FED-STD - Federal Standard; (See FS).

5. FS - Federal Specification; Available from DLA Document Services; www.quicksearch.dla.mil.

   a. Available from Defense Standardization Program; www.dsp.dla.mil.
   b. Available from General Services Administration; www.gsa.gov.
   c. Available from National Institute of Building Sciences/Whole Building Design Guide; www.wbdg.org.

6. MILSPEC - Military Specification and Standards; (See DOD).
7. USAB - United States Access Board; www.access-board.gov.
8. USATBCB - U.S. Architectural & Transportation Barriers Compliance Board; (See USAB).

E. State Government Agencies: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.

   1. xxx,

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 014200

# SECTION 015000 - TEMPORARY FACILITIES AND CONTROLS

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes requirements for temporary utilities, support facilities, and security and protection facilities.

B. Related Requirements:

1. Section 011000 "Summary" for work restrictions and limitations on utility interruptions.

### 1.2 USE CHARGES

A. Installation, removal, and use charges for temporary facilities shall be included in the Contract Sum unless otherwise indicated. Allow other entities engaged in the Project to use temporary services and facilities without cost, including, but not limited to, Owner's construction forces, Engineer, occupants of Project, testing agencies, and authorities having jurisdiction.

B. Water and Sewer Service from Existing System: Water from Owner's existing water system is available for use without metering and without payment of use charges. Provide connections and extensions of services as required for construction operations.

C. Electric Power Service from Existing System: Electric power from Owner's existing system is available for use without metering and without payment of use charges. Provide connections and extensions of services as required for construction operations.

### 1.3 INFORMATIONAL SUBMITTALS

A. Site Utilization Plan: Show temporary facilities, temporary utility lines and connections, staging areas, construction site entrances, vehicle circulation, and parking areas for construction personnel.

B. Project Identification and Temporary Signs: Show fabrication and installation details, including plans, elevations, details, layouts, typestyles, graphic elements, and message content.

C. Fire-Safety Program: Show compliance with requirements of NFPA 241 and authorities having jurisdiction. Indicate Contractor personnel responsible for management of fire-prevention program.

D. Moisture- and Mold-Protection Plan: Describe procedures and controls for protecting materials and construction from water absorption and damage and mold. Describe delivery, handling, storage, installation, and protection provisions for materials subject to water absorption or water damage.

1. Indicate procedures for discarding water-damaged materials, protocols for mitigating water intrusion into completed Work, and requirements for replacing water-damaged Work.
2. Indicate sequencing of work that requires water, such as sprayed fire-resistive materials, plastering, and terrazzo grinding, and describe plans for dealing with water from these operations. Show procedures for verifying that wet construction has dried sufficiently to permit installation of finish materials.
3. Indicate methods to be used to avoid trapping water in finished work.

## 1.4 QUALITY ASSURANCE

A. Electric Service: Comply with NECA, NEMA, and UL standards and regulations for temporary electric service. Install service to comply with NFPA 70.

B. Tests and Inspections: Arrange for authorities having jurisdiction to test and inspect each temporary utility before use. Obtain required certifications and permits.

C. Accessible Temporary Egress: Comply with applicable provisions in the United States Access Board's ADA-ABA Accessibility Guidelines and ICC/ANSI A117.1.

# PART 2 - PRODUCTS

## 2.1 TEMPORARY FACILITIES

## 2.2 EQUIPMENT

A. Fire Extinguishers: Portable, UL rated; with class and extinguishing agent as required by locations and classes of fire exposures.

B. HVAC Equipment: Unless Owner authorizes use of permanent HVAC system, provide vented, self-contained, liquid-propane-gas or fuel-oil heaters with individual space thermostatic control.

1. Use of gasoline-burning space heaters, open-flame heaters, or salamander-type heating units is prohibited.
2. Heating, Cooling, and Dehumidifying Units: Listed and labeled for type of fuel being consumed, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
3. Permanent HVAC System: If Owner authorizes use of permanent HVAC system for temporary use during construction, provide filter with MERV of 8 at each return-air grille in system and remove at end of construction and clean HVAC system as required in Section 017700 "Closeout Procedures."

C. Air-Filtration Units: Primary and secondary HEPA-filter-equipped portable units with four-stage filtration. Provide single switch for emergency shutoff. Configure to run continuously.

## PART 3 - EXECUTION

### 3.1 TEMPORARY FACILITIES, GENERAL

A. Conservation: Coordinate construction and use of temporary facilities with consideration given to conservation of energy, water, and materials. Coordinate use of temporary utilities to minimize waste.

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

### 3.2 INSTALLATION, GENERAL

A. Locate facilities where they will serve Project adequately and result in minimum interference with performance of the Work. Relocate and modify facilities as required by progress of the Work.

B. Provide each facility ready for use when needed to avoid delay. Do not remove until facilities are no longer needed or are replaced by authorized use of completed permanent facilities.

### 3.3 SUPPORT FACILITIES INSTALLATION

A. Traffic Controls: Comply with requirements of authorities having jurisdiction.

1. Protect existing site improvements to remain including curbs, pavement, and utilities.
2. Maintain access for fire-fighting equipment and access to fire hydrants.

B. Parking: Use designated areas of Owner's existing parking areas for construction personnel.

C. Storage and Staging: Use designated areas of Project site for storage and staging needs.

D. Waste Disposal Facilities: Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."

E. Lifts and Hoists: Provide facilities necessary for hoisting materials and personnel.

1. Truck cranes and similar devices used for hoisting materials are considered "tools and equipment" and not temporary facilities.

F. Existing Stair Usage: Use of Owner's existing stairs will be permitted, provided stairs are cleaned and maintained in a condition acceptable to Owner. At Substantial Completion, restore stairs to condition existing before initial use.

1. Provide protective coverings, barriers, devices, signs, or other procedures to protect stairs and to maintain means of egress. If stairs become damaged, restore damaged areas so no evidence remains of correction work.

## 3.4 SECURITY AND PROTECTION FACILITIES INSTALLATION

A. Protection of Existing Facilities: Protect existing vegetation, equipment, structures, utilities, and other improvements at Project site and on adjacent properties, except those indicated to be removed or altered. Repair damage to existing facilities.

1. Where access to adjacent properties is required in order to affect protection of existing facilities, obtain written permission from adjacent property owner to access property for that purpose.

B. Environmental Protection: Provide protection, operate temporary facilities, and conduct construction as required to comply with environmental regulations and that minimize possible air, waterway, and subsoil contamination or pollution or other undesirable effects.

C. Barricades, Warning Signs, and Lights: Comply with requirements of authorities having jurisdiction for erecting structurally adequate barricades, including warning signs and lighting.

D. Temporary Egress: Provide temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction. Provide signage directing occupants to temporary egress.

E. Temporary Enclosures: Provide temporary enclosures for protection of construction, in progress and completed, from exposure, foul weather, other construction operations, and similar activities. Provide temporary weathertight enclosure for building exterior.

1. Where heating or cooling is needed and permanent enclosure is incomplete, insulate temporary enclosures.

F. Temporary Partitions: Provide floor-to-ceiling dustproof partitions to limit dust and dirt migration and to separate areas occupied by Owner from fumes and noise.

1. Construct dustproof partitions with gypsum wallboard with joints taped on occupied side, and fire-retardant-treated plywood on construction operations side.
2. Where fire-resistance-rated temporary partitions are indicated or are required by authorities having jurisdiction, construct partitions according to the rated assemblies.
3. Provide walk-off mats at each entrance through temporary partition.

G. Temporary Fire Protection: Install and maintain temporary fire-protection facilities of types needed to protect against reasonably predictable and controllable fire losses. Comply with NFPA 241; manage fire-prevention program.

1. Prohibit smoking in construction areas. Comply with additional limits on smoking specified in other Sections.
2. Supervise welding operations, combustion-type temporary heating units, and similar sources of fire ignition according to requirements of authorities having jurisdiction.

3. Develop and supervise an overall fire-prevention and -protection program for personnel at Project site. Review needs with local fire department and establish procedures to be followed. Instruct personnel in methods and procedures. Post warnings and information.
4. Provide temporary standpipes and hoses for fire protection. Hang hoses with a warning sign stating that hoses are for fire-protection purposes only and are not to be removed. Match hose size with outlet size and equip with suitable nozzles.

## 3.5 OPERATION, TERMINATION, AND REMOVAL

A. Supervision: Enforce strict discipline in use of temporary facilities. To minimize waste and abuse, limit availability of temporary facilities to essential and intended uses.

B. Maintenance: Maintain facilities in good operating condition until removal.

1. Maintain operation of temporary enclosures, heating, cooling, humidity control, ventilation, and similar facilities on a 24-hour basis where required to achieve indicated results and to avoid possibility of damage.

C. Temporary Facility Changeover: Do not change over from using temporary security and protection facilities to permanent facilities until Substantial Completion.

D. Termination and Removal: Remove each temporary facility when need for its service has ended, when it has been replaced by authorized use of a permanent facility, or no later than Substantial Completion. Complete or, if necessary, restore permanent construction that may have been delayed because of interference with temporary facility. Repair damaged Work, clean exposed surfaces, and replace construction that cannot be satisfactorily repaired.

1. Materials and facilities that constitute temporary facilities are property of Contractor. Owner reserves right to take possession of Project identification signs.
2. At Substantial Completion, repair, renovate, and clean permanent facilities used during construction period. Comply with final cleaning requirements specified in Section 017700 "Closeout Procedures."

END OF SECTION 015000

SECTION 016000 - PRODUCT REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for selection of products for use in Project; product delivery, storage, and handling; manufacturers' standard warranties on products; special warranties; and comparable products.

B. Related Requirements:

1. Section 012500 "Substitution Procedures" for requests for substitutions.

1.2 DEFINITIONS

A. Products: Items obtained for incorporating into the Work, whether purchased for Project or taken from previously purchased stock. The term "product" includes the terms "material," "equipment," "system," and terms of similar intent.

1. Named Products: Items identified by manufacturer's product name, including make or model number or other designation shown or listed in manufacturer's published product literature that is current as of date of the Contract Documents.
2. New Products: Items that have not previously been incorporated into another project or facility. Salvaged items or items reused from other projects are not considered new products. Items that are manufactured or fabricated to include recycled content materials are considered new products, unless indicated otherwise.
3. Comparable Product: Product by named manufacturer that is demonstrated and approved through the comparable product submittal process described in Part 2 "Comparable Products" Article, to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

B. Basis-of-Design Product Specification: A specification in which a single manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation. Published attributes and characteristics of basis-of-design product establish salient characteristics of products.

1. Evaluation of Comparable Products: In addition to the basis-of-design product description, product attributes and characteristics may be listed to establish the significant qualities related to type, function, in-service performance and physical properties, weight, dimension, durability, visual characteristics, and other special features and requirements for purposes of evaluating comparable products of additional manufacturers named in the specification. Manufacturer's published attributes and characteristics of basis-of-design product also establish salient characteristics of products for purposes of evaluating comparable products.

C. Subject to Compliance with Requirements: Where the phrase "Subject to compliance with requirements" introduces a product selection procedure in an individual Specification Section, provide products qualified under the specified product procedure. In the event that a named product or product by a named manufacturer does not meet the other requirements of the specifications, select another named product or product from another named manufacturer that does meet the requirements of the specifications; submit a comparable product request or substitution request, if applicable.

D. Comparable Product Request Submittal: An action submittal requesting consideration of a comparable product, including the following information:

1. Identification of basis-of-design product or fabrication or installation method to be replaced, including Specification Section number and title and Drawing numbers and titles.
2. Data indicating compliance with the requirements specified in Part 2 "Comparable Products" Article.

E. Basis-of-Design Product Specification Submittal: An action submittal complying with requirements in Section 013300 "Submittal Procedures."

F. Substitution: Refer to Section 012500 "Substitution Procedures" for definition and limitations on substitutions.

## 1.3 QUALITY ASSURANCE

A. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, select product compatible with products previously selected, even if previously selected products were also options.

## 1.4 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products, using means and methods that will prevent damage, deterioration, and loss, including theft and vandalism. Comply with manufacturer's written instructions.

## 1.5 PRODUCT WARRANTIES

A. Warranties specified in other Sections shall be in addition to, and run concurrent with, other warranties required by the Contract Documents. Manufacturer's disclaimers and limitations on product warranties do not relieve Contractor of obligations under requirements of the Contract Documents.

1. Manufacturer's Warranty: Written standard warranty form furnished by individual manufacturer for a particular product and issued in the name of the Owner or endorsed by manufacturer to Owner.
2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for Owner and issued in the name of the Owner or endorsed by manufacturer to Owner.

B. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution.

1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed.
2. Specified Form: When specified forms are included in the Project Manual, prepare a written document, using indicated form properly executed.
3. See other Sections for specific content requirements and particular requirements for submitting special warranties.

## PART 2 - PRODUCTS

### 2.1 PRODUCT SELECTION PROCEDURES

A. General Product Requirements: Provide products that comply with the Contract Documents, are undamaged and, unless otherwise indicated, are new at time of installation.

1. Provide products complete with accessories, trim, finish, fasteners, and other items needed for a complete installation and indicated use and effect.
2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.
3. Owner reserves the right to limit selection to products with warranties meeting requirements of the Contract Documents.
4. Where products are accompanied by the term "as selected," Engineer will make selection.
5. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.

B. Product Selection Procedures:

1. Sole Manufacturer/Source: Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

   a. Sole manufacturer/source may be indicated by the phrase "Subject to compliance with requirements, provide products by the following."

2. Limited List of Products: Where Specifications include a list of names of both manufacturers and products, provide one of the products listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

   a. Limited list of products may be indicated by the phrase "Subject to compliance with requirements, provide one of the following."

3. Non-Limited List of Products: Where Specifications include a list of names of both available manufacturers and products, provide one of the products listed or an unnamed product that complies with requirements.

    a. Non-limited list of products is indicated by the phrase "Subject to compliance with requirements, available products that may be incorporated in the Work include, but are not limited to, the following."
    b. Provision of an unnamed product is not considered a substitution, if the product complies with requirements.

4. Limited List of Manufacturers: Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.

    a. Limited list of manufacturers is indicated by the phrase "Subject to compliance with requirements, provide products by one of the following."

5. Non-Limited List of Manufacturers: Where Specifications include a list of available manufacturers, provide a product by one of the manufacturers listed or a product by an unnamed manufacturer that complies with requirements.

    a. Non-limited list of manufacturers is indicated by the phrase "Subject to compliance with requirements, available manufacturers whose products may be incorporated in the Work include, but are not limited to, the following."
    b. Provision of products of an unnamed manufacturer is not considered a substitution, if the product complies with requirements.

6. Basis-of-Design Product: Where Specifications name a product, or refer to a product indicated on Drawings, and include a list of manufacturers, provide the specified or indicated product or a comparable product by one of the other named manufacturers. Drawings and Specifications may additionally indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with requirements in "Comparable Products" Article for consideration of an unnamed product by one of the other named manufacturers.

    a. For approval of products by unnamed manufacturers, comply with requirements in Section 012500 "Substitution Procedures" for substitutions for convenience.

C. Visual Matching Specification: Where Specifications require the phrase "match Engineer's sample," provide a product that complies with requirements and matches Engineer's sample. Engineer's decision will be final on whether a proposed product matches.

    1. If no product available within specified category matches and complies with other specified requirements, comply with requirements in Section 012500 "Substitution Procedures" for proposal of product.

D. Visual Selection Specification: Where Specifications include the phrase "as selected by Engineer from manufacturer's full range" or a similar phrase, select a product that complies with requirements. Engineer will select color, gloss, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.

E. Sustainable Product Selection: Where Specifications require product to meet sustainable product characteristics, select products complying with indicated requirements. Comply with requirements in Division 01 sustainability requirements Section and individual Specification Sections.

1. Select products for which sustainable design documentation submittals are available from manufacturer.

## 2.2 COMPARABLE PRODUCTS

A. Conditions for Consideration of Comparable Products: Engineer will consider Contractor's request for comparable product when the following conditions are satisfied. If the following conditions are not satisfied, Engineer may return requests without action, except to record noncompliance with the following requirements:

1. Evidence that proposed product does not require revisions to the Contract Documents, is consistent with the Contract Documents, will produce the indicated results, and is compatible with other portions of the Work.
2. Detailed comparison of significant qualities of proposed product with those of the named basis-of-design product. Significant product qualities include attributes, such as type, function, in-service performance and physical properties, weight, dimension, durability, visual characteristics, and other specific features and requirements.
3. Evidence that proposed product provides specified warranty.
4. List of similar installations for completed projects, with project names and addresses and names and addresses of Engineers and owners, if requested.
5. Samples, if requested.

B. Engineer's Action on Comparable Products Submittal: If necessary, Engineer will request additional information or documentation for evaluation, as specified in Section 013300 "Submittal Procedures."

1. Form of Approval of Submittal: As specified in Section 013300 "Submittal Procedures."
2. Use product specified if Engineer does not issue a decision on use of a comparable product request within time allocated.

C. Submittal Requirements, Two-Step Process: Approval by the Engineer of Contractor's request for use of comparable product is not intended to satisfy other submittal requirements. Comply with specified submittal requirements.

D. Submittal Requirements, Single-Step Process: When acceptable to Engineer, incorporate specified submittal requirements of individual Specification Section in combined submittal for comparable products. Approval by the Engineer of Contractor's request for use of comparable product and of individual submittal requirements will also satisfy other submittal requirements.

# PART 3 - EXECUTION (Not Used)

END OF SECTION 016000

SECTION 017300 - EXECUTION

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes general administrative and procedural requirements governing execution of the Work, including, but not limited to, the following:

1. Construction layout.
2. Field engineering and surveying.
3. Installation of the Work.
4. Cutting and patching.
5. Coordination of Owner's portion of the Work.
6. Coordination of Owner-installed products.
7. Progress cleaning.
8. Starting and adjusting.
9. Protection of installed construction.

B. Related Requirements:

1. Section 017700 "Closeout Procedures" for submitting final property survey with Project Record Documents, recording of Owner-accepted deviations from indicated lines and levels, replacing defective work, and final cleaning.

1.2 DEFINITIONS

A. Cutting: Removal of in-place construction necessary to permit installation or performance of subsequent work.

B. Patching: Fitting and repair work required to restore construction to original conditions after installation of subsequent work.

1.3 QUALITY ASSURANCE

A. Cutting and Patching: Comply with requirements for and limitations on cutting and patching of construction elements.

1. Structural Elements: When cutting and patching structural elements, or when encountering the need for cutting and patching of elements whose structural function is not known, notify Engineer of locations and details of cutting and await directions from Engineer before proceeding. Shore, brace, and support structural elements during cutting and patching. Do not cut and patch structural elements in a manner that could change their load-carrying capacity or increase deflection.
2. 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.

3. Other Construction Elements: Do not cut and patch other construction elements or 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.
4. Visual Elements: Do not cut and patch construction in a manner that results in visual evidence of cutting and patching. Do not cut and patch exposed construction in a manner that would, in Engineer's opinion, reduce the building's aesthetic qualities. Remove and replace construction that has been cut and patched in a visually unsatisfactory manner.

B. Manufacturer's Installation Instructions: Obtain and maintain on-site manufacturer's written recommendations and instructions for installation of specified products and equipment.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Comply with requirements specified in other Sections.

1. For projects requiring compliance with sustainable design and construction practices and procedures, use products for patching that comply with sustainable design requirements.

B. In-Place Materials: Use materials for patching 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 provide a match acceptable to Engineer for the visual and functional performance of in-place materials. Use materials that are not considered hazardous.

C. 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.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examination and Acceptance of Conditions: Before proceeding with each component of the Work, examine substrates, areas, and conditions, with Installer or Applicator present where indicated, for compliance with requirements for installation tolerances and other conditions affecting performance. Record observations.

1. Examine roughing-in for mechanical and electrical systems to verify actual locations of connections before equipment and fixture installation.
2. Examine walls, floors, and roofs for suitable conditions where products and systems are to be installed.

3. Verify compatibility with and suitability of substrates, including compatibility with existing finishes or primers.

B. Written Report: Where a written report listing conditions detrimental to performance of the Work is required by other Sections, include the following:

1. Description of the Work, including Specification Section number and paragraph, and Drawing sheet number and detail, where applicable.
2. List of detrimental conditions, including substrates.
3. List of unacceptable installation tolerances.
4. Recommended corrections.

C. Proceed with installation only after unsatisfactory conditions have been corrected. Proceeding with the Work indicates acceptance of surfaces and conditions.

## 3.2 PREPARATION

A. Existing Utility Information: Furnish information to Owner that is necessary to adjust, move, or relocate existing utility structures, utility poles, lines, services, or other utility appurtenances located in or affected by construction. Coordinate with authorities having jurisdiction.

B. Field Measurements: Take field measurements as required to fit the Work properly. Recheck measurements before installing each product. Where portions of the Work are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

C. Space Requirements: Verify space requirements and dimensions of items shown diagrammatically on Drawings.

D. Review of Contract Documents and Field Conditions: Immediately on discovery of the need for clarification of the Contract Documents, submit a request for information to Engineer in accordance with requirements in Section 013100 "Project Management and Coordination."

## 3.3 INSTALLATION

A. Locate the Work and components of the Work accurately, in correct alignment and elevation, as indicated.

1. Make vertical work plumb, and make horizontal work level.
2. Where space is limited, install components to maximize space available for maintenance and ease of removal for replacement.
3. Conceal pipes, ducts, and wiring in finished areas unless otherwise indicated.
4. Maintain minimum headroom clearance of 96 inches in occupied spaces and 90 inches in unoccupied spaces, unless otherwise indicated on Drawings.

B. Comply with manufacturer's written instructions and recommendations for installing products in applications indicated.

C. Install products at the time and under conditions that will ensure satisfactory results as judged by Engineer. Maintain conditions required for product performance until Substantial Completion.

D. Conduct construction operations, so no part of the Work is subjected to damaging operations or loading in excess of that expected during normal conditions of occupancy of type expected for Project.

E. Sequence the Work and allow adequate clearances to accommodate movement of construction items on-site and placement in permanent locations.

F. Tools and Equipment: Select tools or equipment that minimize production of excessive noise levels.

G. Templates: Obtain and distribute to the parties involved templates for Work specified to be factory prepared and field installed. Check Shop Drawings of other portions of the Work to confirm that adequate provisions are made for locating and installing products to comply with indicated requirements.

H. Attachment: Provide blocking and attachment plates and anchors and fasteners of adequate size and number to securely anchor each component in place, accurately located and aligned with other portions of the Work. Where size and type of attachments are not indicated, verify size and type required for load conditions with manufacturer.

1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Engineer.
2. Allow for building movement, including thermal expansion and contraction.
3. Coordinate installation of anchorages. Furnish setting drawings, templates, and directions for installing anchorages, including sleeves, concrete inserts, anchor bolts, and items with integral anchors, that are to be embedded in concrete or masonry. Deliver such items to Project site in time for installation.

I. Joints: Make joints of uniform width. Where joint locations in exposed Work are not indicated, arrange joints for the best visual effect, as judged by Engineer. Fit exposed connections together to form hairline joints.

J. Repair or remove and replace damaged, defective, or nonconforming Work.

1. Comply with Section 017700 "Closeout Procedures" for repairing or removing and replacing defective Work.

## 3.4 CUTTING AND PATCHING

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

C. Temporary Support: Provide temporary support of Work to be cut.

D. 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.

E. Adjacent Occupied Areas: Where interference with use of adjoining areas or interruption of free passage to adjoining areas is unavoidable, coordinate cutting and patching in accordance with requirements in Section 011000 "Summary."

F. 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 minimize interruption to occupied areas.

G. 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 neatly to minimum 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 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.

H. 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 practicable, as judged by Engineer. Provide materials and comply with installation requirements specified in other Sections, where applicable.

1. Inspection: Where feasible, test and inspect patched areas after completion to demonstrate physical 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, prepare substrate and apply primer and intermediate paint coats appropriate for substrate over the patch, and apply final paint coat over entire unbroken surface containing the patch, corner to corner of wall and edge to edge of ceiling. 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 and ensures thermal and moisture integrity of building enclosure.

I. Cleaning: Clean areas and spaces where cutting and patching are performed. Remove paint, mortar, oils, putty, and similar materials from adjacent finished surfaces.

## 3.5 PROGRESS CLEANING

A. Clean Project site and work areas daily, including common areas. Enforce requirements strictly. Dispose of materials lawfully.

1. Comply with requirements in NFPA 241 for removal of combustible waste materials and debris.
2. Do not hold waste materials more than seven days during normal weather or three days if the temperature is expected to rise above 80 deg F.
3. Containerize hazardous and unsanitary waste materials separately from other waste. Mark containers appropriately and dispose of legally, according to regulations.

    a. Use containers intended for holding waste materials of type to be stored.

4. Coordinate progress cleaning for joint-use areas where Contractor and other contractors are working concurrently.

B. Site: Maintain Project site free of waste materials and debris.

C. Work Areas: Clean areas where Work is in progress to the level of cleanliness necessary for proper execution of the Work.

1. Remove liquid spills promptly.
2. Where dust would impair proper execution of the Work, broom-clean or vacuum the entire work area, as appropriate.

D. Installed Work: Keep installed work clean. Clean installed surfaces according to written instructions of manufacturer or fabricator of product installed, using only cleaning materials specifically recommended. If specific cleaning materials are not recommended, use cleaning materials that are not hazardous to health or property and that will not damage exposed surfaces.

E. Concealed Spaces: Remove debris from concealed spaces before enclosing the space.

F. Exposed Surfaces: Clean exposed surfaces and protect as necessary to ensure freedom from damage and deterioration at time of Substantial Completion.

G. Waste Disposal: Do not bury or burn waste materials on-site. Do not wash waste materials down sewers or into waterways. Comply with waste disposal requirements in Section 017419 "Construction Waste Management and Disposal."

H. During handling and installation, clean and protect construction in progress and adjoining materials already in place. Apply protective covering where required to ensure protection from damage or deterioration at Substantial Completion.

I. Clean and provide maintenance on completed construction as frequently as necessary through the remainder of the construction period. Adjust and lubricate operable components to ensure operability without damaging effects.

J. Limiting Exposures: Supervise construction operations to ensure that no part of the construction, completed or in progress, is subject to harmful, dangerous, damaging, or otherwise deleterious exposure during the construction period.

## 3.6 STARTING AND ADJUSTING

A. Coordinate startup and adjusting of equipment and operating components with commissioning requirements.

B. Start equipment and operating components to confirm proper operation. Remove malfunctioning units, replace with new units, and retest.

C. Adjust equipment for proper operation. Adjust operating components for proper operation without binding.

D. Test each piece of equipment to verify proper operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

E. Manufacturer's Field Service: Comply with qualification requirements in Section 014000 "Quality Requirements."

## 3.7 PROTECTION AND REPAIR OF INSTALLED CONSTRUCTION

A. Provide final protection and maintain conditions that ensure installed Work is without damage or deterioration at time of Substantial Completion.

B. Repair Work previously completed and subsequently damaged during construction period. Repair to like-new condition.

C. Protection of Existing Items: Provide protection and ensure that existing items to remain undisturbed by construction are maintained in condition that existed at commencement of the Work.

D. Comply with manufacturer's written instructions for temperature and relative humidity.

END OF SECTION 017300

# SECTION 017419 - CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section includes administrative and procedural requirements for the following:

1. Disposing of nonhazardous demolition and construction waste.

### 1.2 DEFINITIONS

A. Construction Waste: Building and site improvement materials and other solid waste resulting from construction, remodeling, renovation, or repair operations. Construction waste includes packaging.

B. Demolition Waste: Building and site improvement materials resulting from demolition or selective demolition operations.

C. Disposal: Removal off-site of demolition and construction waste and subsequent sale, recycling, reuse, or deposit in landfill or incinerator acceptable to authorities having jurisdiction.

D. Recycle: Recovery of demolition or construction waste for subsequent processing in preparation for reuse.

E. Salvage: Recovery of demolition or construction waste and subsequent sale or reuse in another facility.

F. Salvage and Reuse: Recovery of demolition or construction waste and subsequent incorporation into the Work.

### 1.3 ACTION SUBMITTALS

A. Waste Management Plan: Submit plan within 30 days of date established for the Notice to Proceed.

### 1.4 INFORMATIONAL SUBMITTALS

A. Landfill and Incinerator Disposal Records: Indicate receipt and acceptance of waste by landfills and incinerator facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

## 1.5 WASTE MANAGEMENT PLAN

A. General: Develop a waste management plan according to ASTM E 1609 and requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan.

B. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Include points of waste generation, total quantity of each type of waste, quantity for each means of recovery, and handling and transportation procedures.

1. Salvaged Materials for Reuse: For materials that will be salvaged and reused in this Project, describe methods for preparing salvaged materials before incorporation into the Work.
2. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
3. Handling and Transportation Procedures: Include method that will be used for separating recyclable waste including sizes of containers, container labeling, and designated location where materials separation will be performed.

# PART 2 - PRODUCTS (Not Used)

# PART 3 - EXECUTION

## 3.1 PLAN IMPLEMENTATION

A. General: Implement approved waste management plan. Provide handling, containers, storage, signage, transportation, and other items as required to implement waste management plan during the entire duration of the Contract.

B. Site Access and Temporary Controls: Conduct waste management operations to ensure minimum interference with roads, streets, walks, walkways, and other adjacent occupied and used facilities.

1. Designate and label specific areas on Project site necessary for separating materials that are to be salvaged, recycled, reused, donated, and sold.
2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

## 3.2 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged, recycled, or otherwise reused, remove waste materials from Project site and legally dispose of them in a landfill or incinerator acceptable to authorities having jurisdiction.

1. Except as otherwise specified, do not allow waste materials that are to be disposed of accumulate on-site.

2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.

B. Burning: Do not burn waste materials.

C. Burning: Burning of waste materials is permitted only at designated areas on Owner's property, provided required permits are obtained. Provide full-time monitoring for burning materials until fires are extinguished.

D. Disposal: Remove waste materials from Owner's property and legally dispose of them.

END OF SECTION 017419

SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 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.

B. Related Requirements:

1. Section 017823 "Operation and Maintenance Data" for additional operation and maintenance manual requirements.
2. Section 017839 "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
3. Section 017900 "Demonstration and Training" for requirements to train the Owner's maintenance personnel to adjust, operate, and maintain products, equipment, and systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of cleaning agent.

B. Contractor's List of Incomplete Items: Initial submittal at Substantial Completion.

C. Certified List of Incomplete Items: Final submittal at Final Completion.

1.3 CLOSEOUT SUBMITTALS

A. Certificates of Release: From authorities having jurisdiction.

B. Certificate of Insurance: For continuing coverage.

C. Field Report: For pest-control inspection.

1.4 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. Submittals 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. Certificates of Release: Obtain and submit releases from authorities having jurisdiction, permitting Owner unrestricted use of the Work and access to services and utilities. Include occupancy permits, operating certificates, and similar releases.
2. Submit closeout submittals specified in other Division 01 Sections, including Project Record Documents, operation and maintenance manuals, damage or settlement surveys, property surveys, and similar final record information.
3. Submit closeout submittals specified in individual Sections, including specific warranties, workmanship bonds, maintenance service agreements, final certifications, and similar documents.
4. Submit maintenance material submittals specified in individual Sections, including tools, spare parts, extra materials, and similar items, and deliver to location designated by the COR. Label with manufacturer's name and model number.
5. Submit testing, adjusting, and balancing records.
6. Submit sustainable design submittals not previously submitted.
7. Submit changeover information related to Owner's occupancy, use, operation, and maintenance.

C. 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. Submit demonstration and training video recordings specified in Section 017900 "Demonstration and Training."
6. Advise Owner of changeover in utility services.
7. Participate with Owner in conducting inspection and walkthrough with local emergency responders.
8. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
9. Complete final cleaning requirements.
10. Touch up paint and otherwise repair and restore marred exposed finishes to eliminate visual defects.

D. 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, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer 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 Engineer, that must be completed or corrected before certificate will be issued.

## 1.5 FINAL COMPLETION PROCEDURES

A. Submittals Prior to Final Completion: Before requesting final inspection for determining Final Completion, complete the following:

1. Submit a final Application for Payment in accordance with Section 012900 "Payment Procedures."
2. Certified List of Incomplete Items: Submit certified copy of Engineer's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed and dated by Engineer. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.
3. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.
4. Submit pest-control final inspection report.

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, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer 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.

## 1.6 LIST OF INCOMPLETE ITEMS

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, listed by room or space number.
2. Organize items applying to each space by major element, including categories for ceilings, 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 Engineer.
    d. Name of Contractor.
    e. Page number.

## 1.7 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Engineer for designated portions of the Work where warranties are indicated to commence on dates other than date of Substantial Completion, or when delay in submittal of warranties might limit Owner's rights under warranty.

B. Organize warranty documents into an orderly sequence based on the table of contents of Project Manual.

C. Warranty Electronic File: Provide warranties and bonds in PDF format. Assemble complete warranty and bond submittal package into a single electronic PDF file with bookmarks enabling navigation to each item. Provide bookmarked table of contents at beginning of document.

1. Submit on digital media acceptable to Engineer.

D. Warranties in Paper Form:

1. Bind warranties and bonds in heavy-duty, three-ring, vinyl-covered, loose-leaf binders, thickness as necessary to accommodate contents, and sized to receive 8-1/2-by-11-inch paper.

E. Provide additional copies of each warranty to include in operation and maintenance manuals.

## 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.

## PART 3 - EXECUTION

### 3.1 FINAL CLEANING

A. 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 of rubbish, waste material, litter, and other foreign substances.
b. 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.
c. Remove debris and surface dust from limited-access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
d. Clean flooring, removing debris, dirt, and staining; clean according to manufacturer's recommendations.
e. Vacuum and mop concrete.
f. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.

g. 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.
h. Remove labels that are not permanent.
i. Wipe surfaces of mechanical and electrical equipment, elevator equipment, and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
j. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
k. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
l. 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 NADCA ACR.

m. Clean luminaires, lamps, globes, and reflectors to function with full efficiency.
n. Clean strainers.
o. Leave Project clean and ready for occupancy.

C. Construction Waste Disposal: Comply with waste-disposal requirements in Section 017419 "Construction Waste Management and Disposal."

## 3.2 REPAIR OF THE WORK

A. Complete repair and restoration operations required by Section 017300 "Execution" before requesting inspection for determination of Substantial Completion.

END OF SECTION 017700

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for preparing operation and maintenance manuals, including the following:

1. Operation and maintenance documentation directory manuals.
2. Emergency manuals.
3. Systems and equipment operation manuals.
4. Systems and equipment maintenance manuals.
5. Product maintenance manuals.

1.2 CLOSEOUT SUBMITTALS

A. Submit operation and maintenance manuals indicated. Provide content for each manual as specified in individual Specification Sections, and as reviewed and approved at the time of Section submittals. Submit reviewed manual content formatted and organized as required by this Section.

1. Engineer and Commissioning Authority will comment on whether content of operation and maintenance submittals is acceptable.
2. Where applicable, clarify and update reviewed manual content to correspond to revisions and field conditions.

B. Format: Submit operation and maintenance manuals in the following format:

1. Submit on digital media acceptable to Owner. Enable reviewer comments on draft submittals.

C. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Engineer and Commissioning Authority will return copy with comments.

1. Correct or revise each manual to comply with Engineer's and Commissioning Authority's comments. Submit copies of each corrected manual within 15 days of receipt of Engineer's and Commissioning Authority's comments and prior to commencing demonstration and training.

## 1.3 FORMAT OF OPERATION AND MAINTENANCE MANUALS

A. Manuals, Electronic Files: Submit manuals in the form of a multiple file composite electronic PDF file for each manual type required.

1. Electronic Files: Use electronic files prepared by manufacturer where available. Where scanning of paper documents is required, configure scanned file for minimum readable file size.
2. File Names and Bookmarks: Bookmark individual documents based on file names. Name document files to correspond to system, subsystem, and equipment names used in manual directory and table of contents. Group documents for each system and subsystem into individual composite bookmarked files, then create composite manual, so that resulting bookmarks reflect the system, subsystem, and equipment names in a readily navigated file tree. Configure electronic manual to display bookmark panel on opening file.

## 1.4 REQUIREMENTS FOR EMERGENCY, OPERATION, AND MAINTENANCE MANUALS

A. Organization of Manuals: 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: 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 and contact information for Contractor.
6. Name and contact information for Engineer.
7. Name and contact information for Commissioning Authority.
8. Names and contact information for major consultants to the Engineer that designed the systems contained in the manuals.
9. 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.

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.

E. Identification: In the documentation directory and in each operation and maintenance manual, identify each system, subsystem, and piece of equipment with same designation used in the Contract Documents. If no designation exists, assign a designation according to ASHRAE Guideline 4, "Preparation of Operating and Maintenance Documentation for Building Systems."

## 1.5 SYSTEMS AND EQUIPMENT OPERATION MANUALS

A. Systems and Equipment Operation Manual: Assemble a complete set of data indicating operation of each system, subsystem, and piece of equipment not part of a system. Include information required for daily operation and management, operating standards, and routine and special operating procedures.

B. 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. Use designations for systems and equipment indicated on Contract Documents.
2. Performance and design criteria if Contractor has 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.

C. Descriptions: Include the following:

1. Product name and model number. Use designations for products indicated on Contract Documents.
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.

D. 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.

E. Emergency Instructions: Describe and explain warnings, trouble indications, error messages, and similar codes and signals. Include responsibilities of Owner's operating personnel for notification of Installer, supplier, and manufacturer to maintain warranties.

F. Emergency Procedures: Include the following, as applicable:

1. Instructions on stopping.
2. Shutdown instructions for each type of emergency.
3. Operating instructions for conditions outside normal operating limits.
4. Required sequences for electric or electronic systems.
5. Special operating instructions and procedures.

G. Systems and Equipment Controls: Describe the sequence of operation, and diagram controls as installed.

H. Piped Systems: Diagram piping as installed and identify color coding where required for identification.

## 1.6 SYSTEMS AND EQUIPMENT MAINTENANCE MANUALS

A. Systems and Equipment Maintenance Manuals: Assemble a complete set of data indicating maintenance of each system, subsystem, and piece of equipment not part of a system. Include manufacturers' maintenance documentation, preventive maintenance procedures and frequency, repair procedures, wiring and systems diagrams, lists of spare parts, and warranty information.

B. 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 warranties and bonds, as described below.

C. Manufacturers' Maintenance Documentation: Include the following information for each component part or piece of equipment:

1. Standard maintenance instructions and bulletins; 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.

   a. 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.

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 video recording, 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.

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. 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.

H. 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.

END OF SECTION 017823

SECTION 017839 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for Project Record Documents, including the following:

1. Record Drawings.
2. Record specifications.
3. Record Product Data.

B. Related Requirements:

1. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.

1.2 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit one set(s) of marked-up record prints.
2. Number of Copies: Submit copies of Record Drawings as follows:

a. Initial Submittal:

1) Submit PDF electronic files of scanned record prints.
2) Engineer will indicate whether general scope of changes, additional information recorded, and quality of drafting are acceptable.

b. Final Submittal:

1) Submit Autocad Format .dwg and PDF electronic files of scanned Record Prints.
2) Submit each drawing, whether or not changes and additional information were recorded.

B. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.

1. Where record Product Data are required as part of operation and maintenance manuals, submit duplicate marked-up Product Data as a component of manual.

## 1.3 RECORD DRAWINGS

A. Record Prints: Maintain one set of marked-up paper copies of the Contract Drawings and Shop Drawings, incorporating new and revised drawings as modifications are issued.

1. Preparation: Mark record prints 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 provide information for preparation of corresponding 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 acceptable drawing technique.
    c. Record data as soon as possible after obtaining it.
    d. Record and check the markup before enclosing concealed installations.
    e. Cross-reference record prints to corresponding photographic documentation.

2. Content: Types of items requiring marking include, but are not limited to, the following:

    a. Dimensional changes to Drawings.
    b. Revisions to details shown on Drawings.
    c. Depths of foundations.
    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 or Construction Change Directive.
    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 and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.
4. Mark record prints 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.

## 1.4 RECORD PRODUCT DATA

A. Recording: Maintain one copy of each submittal during the construction period for Project Record Document purposes. Post changes and revisions to Project Record Documents as they occur; do not wait until end of Project.

B. 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. Include significant changes in the product delivered to Project site and changes in manufacturer's written instructions for installation.
3. Note related Change Orders, Record Specifications, and Record Drawings where applicable.

C. Format: Submit Record Product Data as annotated PDF electronic file.

1. Include Record Product Data directory organized by Specification Section number and title, electronically linked to each item of Record Product Data.

## 1.5 MAINTENANCE OF RECORD DOCUMENTS

A. Maintenance of Record Documents: Store Record Documents 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 Engineer's reference during normal working hours.

END OF SECTION 017839

SECTION 017900 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including instruction in operation and maintenance of systems, subsystems, and equipment.

1.2 INFORMATIONAL SUBMITTALS

A. Instruction Program: Submit outline of instructional program for demonstration and training, including a list of training modules and a schedule of proposed dates, times, length of instruction time, and instructors' names for each training module. Include learning objective and outline for each training module.

1. Indicate proposed training modules using manufacturer-produced demonstration and training video recordings for systems, equipment, and products in lieu of video recording of live instructional module.

1.3 QUALITY ASSURANCE

A. Facilitator Qualifications: A firm or individual experienced in training or educating maintenance personnel in a training program similar in content and extent to that indicated for this Project, and whose work has resulted in training or education with a record of successful learning performance.

B. Instructor Qualifications: A factory-authorized service representative, experienced in operation and maintenance procedures and training.

1.4 COORDINATION

A. Coordinate instruction schedule with Owner's operations. Adjust schedule as required to minimize disrupting Owner's operations and to ensure availability of Owner's personnel.

B. Coordinate instructors, including providing notification of dates, times, length of instruction time, and course content.

C. Coordinate content of training modules with content of approved emergency, operation, and

1.5 INSTRUCTION PROGRAM

A. Program Structure: Develop an instruction program that includes individual training modules for each system and for equipment not part of a system, as required by individual Specification Sections.

B. Training Modules: Develop a learning objective and teaching outline for each module. Include a description of specific skills and knowledge that participant is expected to master. For each module, include instruction for the following as applicable to the system, equipment, or component:

1. 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.

2. Documentation: Review the following items in detail:

   a. Emergency manuals.
   b. Systems and equipment operation manuals.
   c. Systems and equipment maintenance manuals.
   d. Product maintenance manuals.
   e. Project Record Documents.
   f. Identification systems.
   g. Warranties and bonds.
   h. Maintenance service agreements and similar continuing commitments.

3. 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.

4. 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.

5. Adjustments: Include the following:

a. Alignments.
b. Checking adjustments.
c. Noise and vibration adjustments.
d. Economy and efficiency adjustments.

6. Troubleshooting: Include the following:

a. Diagnostic instructions.
b. Test and inspection procedures.

7. 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.

8. 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.

## 1.6 INSTRUCTION

A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.

B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.

C. Scheduling: Provide instruction at mutually agreed-on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.

1. Schedule training with Owner, through Engineer, with at least seven days' advance notice.

D. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.

END OF SECTION 017900

# SECTION 024119 - SELECTIVE DEMOLITION

## PART 1 - GENERAL

### 1.1 SUMMARY

A. The Work of this Section Includes:

1. Demolition and removal of selected portions of exterior or interior of building or structure and site elements.
2. Removal and salvage of existing items for delivery to Owner and removal of existing items for reinstallation.

B. Related Requirements:

1. Section 011000 "Summary" for restrictions on use of the premises, Owner-occupancy requirements, and phasing requirements.
2. Section 017300 "Execution" for cutting and patching procedures.
3. Section 330500 "Common Work Results for Utilities" for removal of site utility systems piping, equipment, and components.

### 1.2 MATERIALS OWNERSHIP

A. Unless otherwise indicated, demolition waste becomes property of Contractor.

B. Historic items, relics, antiques, and similar objects including, but not limited to, cornerstones and their contents, commemorative plaques and tablets, and other items of interest or value to Owner that may be uncovered during demolition remain the property of Owner.

1. Carefully salvage in a manner to prevent damage and promptly return to Owner.

### 1.3 INFORMATIONAL SUBMITTALS

A. Survey of Existing Conditions: Submit survey.

B. Proposed Protection Measures: Submit report, including Drawings, that indicates the measures proposed for protecting individuals and property, for environmental protection.

C. Schedule of selective demolition activities with starting and ending dates for each activity.

D. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician.

### 1.4 CLOSEOUT SUBMITTALS

A. Inventory: Submit a list of items that have been removed and salvaged.

## 1.5 FIELD CONDITIONS

A. Owner will not occupy portions of building immediately adjacent to selective demolition area. Conduct selective demolition so Owner's operations will not be disrupted.

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

1. Before start of selective demolition, Contractor shall coordinate a list of items to be removed by the Owner:

C. Notify Architect of discrepancies between existing conditions and Drawings before proceeding with selective demolition.

D. Hazardous Materials:

1. It is not expected that hazardous materials will be encountered in the Work.
   a. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Hazardous materials will be removed by Owner under a separate contract.

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

## 1.6 WARRANTY

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

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

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

B. Standards: Comply with ANSI/ASSP A10.6 and NFPA 241.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Verify that utilities have been disconnected and capped before starting selective demolition operations.

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

C. Survey of Existing Conditions: Record existing conditions by use of preconstruction photographs or measured drawings and templates. Comply with Section 013233 "Photographic Documentation."

1. Inventory and record the condition of items to be removed for salvage or reinstallation. Photograph or video conditions that might be misconstrued as damage caused by removal.
2. Photograph or video existing conditions of adjoining construction including finish surfaces, that might be misconstrued as damage caused by selective demolition operations or removal of items for salvage or reinstallation.

## 3.2 PREPARATION

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

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

C. Refrigerant: Before starting demolition, remove refrigerant from mechanical equipment in accordance with 40 CFR 82 and regulations of authorities having jurisdiction.

## 3.3 UTILITY SERVICES AND BUILDING SYSTEMS

A. Existing Services/Systems to Remain: Maintain utilities and building systems and equipment to remain and protect against damage during selective demolition operations.

B. Existing Services/Systems to Be Removed, Relocated, or Abandoned: Locate, identify, disconnect, and seal or cap off utilities and building systems serving areas to be selectively demolished.

1. Owner will arrange to shut off indicated utilities when requested by Contractor.
2. If disconnection of utilities and building systems will affect adjacent occupied parts of the building, provide temporary services/systems that bypass area of selective demolition and that maintain continuity of services/systems to those parts of the building.
3. Demolish and remove existing building systems, equipment, and components indicated on Drawings to be removed.

    a. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
    b. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.

c. Equipment to Be Removed: Disconnect and cap services and remove equipment and components.

4. Abandon existing building systems, equipment, and components indicated on Drawings to be abandoned in place.

a. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material and leave in place.
b. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material and leave in place.

5. Remove and reinstall/salvage existing building systems, equipment, and components indicated on drawings to be removed and reinstalled or removed and salvaged:

a. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment and components; when appropriate, reinstall, reconnect, and make equipment operational.
b. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and components and deliver to Owner.

## 3.4 SALVAGE/REINSTALL

A. Removed and Salvaged Items:

1. Clean salvaged items.
2. Pack or crate items after cleaning. Identify contents of containers with label indicating elements, date of removal, quantity, and location where removed.
3. Store items in a secure area until delivery to Owner.
4. Transport items to Owner's storage area designated by Owner.
5. Protect items from damage during transport and storage.

B. Removed and Reinstalled Items:

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

## 3.5 SELECTIVE DEMOLITION, GENERAL

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

1. Neatly cut openings and holes plumb, square, and true to dimensions required. Use cutting methods the least likely to damage construction to remain or adjoining

construction. Use hand tools or small power tools designed for sawing or grinding, not hammering and chopping. Temporarily cover openings to remain.

2. Cut or drill from the exposed or finished side into concealed surfaces to avoid marring existing finished surfaces.
3. Do not use cutting torches until work area is cleared of flammable materials. At concealed spaces, such as duct and pipe interiors, verify condition and contents of hidden space before starting flame-cutting operations. Maintain portable fire-suppression devices during flame-cutting operations.
4. Maintain fire watch during and for at least 2 hours after flame-cutting operations.
5. Locate selective demolition equipment and remove debris and materials so as not to impose excessive loads on supporting walls, floors, or framing.

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

## 3.6 DISPOSAL OF DEMOLISHED MATERIALS

A. Remove demolition waste materials from Project site and dispose of them in an EPA-approved construction and demolition waste landfill acceptable to authorities having jurisdiction and recycle or dispose of them in accordance with Section 017419 "Construction Waste Management and Disposal."

1. Do not allow demolished materials to accumulate on-site.
2. Remove and transport debris in a manner that will prevent spillage on adjacent surfaces and areas.
3. Comply with requirements specified in Section 017419 "Construction Waste Management and Disposal."

B. Burning: Do not burn demolished materials.

## 3.7 CLEANING

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

END OF SECTION 024119

SECTION 030130 - MAINTENANCE OF CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Bonding agents.
2. Patching mortar.
3. Preplaced concrete materials.
4. Joint filler.
5. Epoxy crack-injection materials.
6. Corrosion-inhibiting materials.
7. Polymer-overlay materials.
8. Polymer-sealer materials.
9. Composite reinforcement materials.

1.2 ACTION SUBMITTALS

A. Product data.

B. Samples: Cured Samples for each exposed product and for each color and texture specified.

1.3 INFORMATIONAL SUBMITTALS

A. Material certificates.

B. Product test reports.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.1 BONDING AGENTS

A. Epoxy-Modified, Cementitious Bonding and Anticorrosion Agent: Manufactured product that consists of water-insensitive epoxy adhesive, portland cement, and water-based solution of corrosion-inhibiting chemicals that forms a protective film on steel reinforcement.

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

a. ARDEX Americas.
b. Kaufman Products, Inc.

c. MAPEI Corporation.
d. Sika Corporation.
e. Sto Corp.

B. Epoxy Bonding Agent: ASTM C881/C881M, bonding system **Type II** and free of VOCs.

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

a. ChemCo Systems, Inc.
b. MAPEI Corporation.
c. Sika Corporation.
d. Sto Corp.

2.2 PATCHING MORTAR

A. Patching Mortar Requirements:

1. Only use patching mortars that are recommended by manufacturer for each applicable horizontal, vertical, or overhead use orientation.
2. Coarse Aggregate for Patching Mortar: ASTM C33/C33M, Size No. 8, Class 5S washed aggregate. Add to patching-mortar mix only as permitted by patching-mortar manufacturer.

B. Rapid-Strength Cementitious Patching Mortar: Packaged, dry mix for repair of concrete.

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

a. ChemMasters, Inc.
b. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
c. Kaufman Products, Inc.
d. MAPEI Corporation.
e. Sto Corp.
f. Tnemec Company, Inc.
g. W. R. Meadows, Inc.
2. Compressive Strength: Not less than **4000 psi (27.6 MPa)**] within **three** hours when tested in accordance with ASTM C109/C109M.

C. Polymer-Modified, Cementitious Patching Mortar: Packaged, dry mix for repair of concrete and that contains a latex additive as either a dry powder or a separate liquid that is added during mixing.

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

a. ARDEX Americas.
b. Kaufman Products, Inc.
c. MAPEI Corporation.
d. Sika Corporation.
e. W. R. Meadows, Inc.

2. Compressive Strength: Not less than **4000 psi (27.6 MPa)** at **28 days** when tested in accordance with ASTM C109/C109M.

## 2.3 PREPLACED CONCRETE MATERIALS

A. Fine Aggregate for Grout: Fine aggregate in accordance with ASTM C33/C33M, but with 100 percent passing a No. 8 (2.36-mm) sieve, 95 to 100 percent passing a No. 16 (1.18-mm) sieve, 55 to 80 percent passing a No. 30 (0.6-mm) sieve, 30 to 55 percent passing a No. 50 (0.3-mm) sieve, 10 to 30 percent passing a No. 100 (0.15-mm) sieve, zero to 10 percent passing a No. 200 (0.075-mm) sieve, and having a fineness modulus of 1.30 to 2.10.

B. Grout Fluidifier for Grout: ASTM C937.

C. Pozzolans for Grout: ASTM C618.

## 2.4 JOINT FILLER

A. Epoxy Joint Filler: Two-component, semirigid, 100 percent solids, epoxy resin with a Shore A durometer hardness of at least 80 in accordance with ASTM D2240.

B. Polyurea Joint Filler: Two-component, semirigid, 100 percent solids, polyurea resin with a Shore A durometer hardness of at least 80 in accordance with ASTM D2240.

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

   a. ARDEX Americas.
   b. ChemCo Systems, Inc.
   c. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
   d. Kaufman Products, Inc.

C. Color: **Matching existing joint filler**

## 2.5 EPOXY CRACK-INJECTION MATERIALS

A. Epoxy Crack-Injection Adhesive: ASTM C881/C881M, bonding system **Type I;** free of VOCs.

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

   a. ChemCo Systems, Inc.
   b. Euclid Chemical Company (The); a subsidiary of RPM International, Inc.
   c. Kaufman Products, Inc.
   d. MAPEI Corporation.
   e. Sika Corporation.
   f. W. R. Meadows, Inc.

2. Capping Adhesive: Product manufactured for use with crack-injection adhesive by same manufacturer.

3. Color: Provide epoxy crack-injection adhesive and capping adhesive as indicated by manufacturer's designations that blend with existing.

## 2.6 MISCELLANEOUS MATERIALS

A. Curing Materials: For ready-mixed concrete or packaged repair materials.

B. Formwork Materials: Form-facing materials must comply with ACI 301 (ACI 301M) requirements.

C. Water: Potable.

D. Cleaning Agent: Commercial muriatic acid solution.

## 2.7 MIXES

A. General: Mix products, in clean containers, in accordance with manufacturer's written instructions.

B. Dry-Pack Mortar: Mix required type(s) of patching-mortar dry ingredients with just enough liquid to form damp cohesive mixture that can be squeezed by hand into a ball but is not plastic.

C. Concrete Mixture Materials: Ready mixed.

1. ACI Publications: Comply with ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents.

# PART 3 - EXECUTION

## 3.1 CONCRETE MAINTENANCE

A. Have concrete-maintenance work performed only by qualified concrete-maintenance specialist.

B. Comply with manufacturers' written instructions for surface preparation and product application.

## 3.2 EXAMINATION

A. Notify Architect seven days in advance of dates when areas of deteriorated or delaminated concrete and deteriorated reinforcing bars will be located.

B. Locate areas of deteriorated or delaminated concrete using hammer or chain-drag sounding and mark boundaries. Mark areas for removal by simplifying and squaring off boundaries. At columns and walls, make boundaries level and plumb unless otherwise indicated.

C. Perform surveys as the Work progresses to detect hazards resulting from concrete-maintenance work.

## 3.3 PREPARATION

A. Ensure that supervisory personnel are on-site and on duty when concrete-maintenance work begins and during its progress.

B. Protect persons, motor vehicles, surrounding surfaces of building being repaired, building site, plants, and surrounding buildings from harm resulting from concrete-maintenance work.

1. Comply with each product manufacturer's written instructions for protections and precautions.
2. Contain dust and debris generated by concrete-maintenance work and prevent it from reaching the public or adjacent surfaces.
3. Protect floors and other surfaces along haul routes from damage, wear, and staining.
4. Provide supplemental sound-control treatment to isolate removal and dismantling work from other areas of the building.
5. Neutralize and collect alkaline and acid wastes for disposal off Owner's property.

C. Existing Drains: Prior to the start of concrete-maintenance work in an area, test drainage system to ensure that it is functioning properly. Notify Architect immediately of inadequate drainage or blockage. Do not begin concrete-maintenance work in an area until the drainage system is in working order.

1. Prevent solids, such as aggregate or mortar residue, from entering the drainage system. Clean out drains and drain lines that become sluggish or blocked by sand or other materials resulting from concrete-maintenance work.
2. Protect drains from pollutants. Block drains or filter out sediments, allowing only clean water to pass.

D. Preparation for Concrete Removal: Make explorations, probes, and inquiries as necessary to determine condition of construction to be removed in the course of repair.

1. Verify that affected utilities have been disconnected and capped.

E. Reinforcing-Bar Preparation: Remove loose and flaking rust from exposed reinforcing bars by **wire brushing** until only tightly adhered light rust remains.

1. Where section loss of reinforcing bar is more than 25 percent, or 20 percent in two or more adjacent bars, cut bars and remove and replace as indicated on Drawings.
2. Remove additional concrete as necessary to provide at least 3/4-inch (19-mm) clearance at existing and replacement bars.
3. Splice replacement bars to existing bars in accordance with ACI 318 (ACI 318M) by lapping, welding, or using mechanical couplings.

F. Preparation of Floor Joints for Repair: Saw-cut joints full width to edges and depth of spalls, but not less than **3/4 inch (19 mm** deep. Clean out debris and loose concrete; vacuum or blow clear with compressed air.

## 3.4 REMOVAL OF CONCRETE

A. Do not overload structural elements with debris.

B. Remove deteriorated and delaminated concrete by breaking up and dislodging from reinforcement.

C. Where half or more of the perimeter of reinforcing bar is exposed, bond between reinforcing bar and surrounding concrete is broken, or reinforcing bar is corroded, remove concrete from entire perimeter of bar and to provide at least 3/4-inch (19-mm) clearance around bar.

D. Test areas where concrete has been removed by tapping with hammer, and remove additional concrete until unsound and disbonded concrete is completely removed.

E. Provide surfaces with a fractured profile of at least 1/8 inch (3 mm) that are approximately perpendicular or parallel to original concrete surfaces. At columns and walls, make top and bottom surfaces level unless otherwise directed.

F. Thoroughly clean removal areas of loose concrete, dust, and debris.

## 3.5 APPLICATION OF BONDING AGENTS

A. Epoxy-Modified, Cementitious Bonding and Anticorrosion System: Apply to reinforcing bars and concrete. Apply to reinforcing bars in two coats, allowing first coat to dry two to three hours before applying second coat. Allow to dry before placing patching mortar.

B. Slurry Coat for Cementitious Patching Mortar: Wet substrate thoroughly and then remove standing water. Scrub a slurry of neat patching mortar[ **mixed with latex bonding agent**] into substrate, filling pores and voids.

## 3.6 INSTALLATION OF PATCHING MORTAR

A. Place patching mortar as specified in this article unless otherwise recommended in writing by manufacturer.

1. Provide forms where necessary to confine patch to required shape.
2. Wet substrate and forms thoroughly and then remove standing water.

B. Pretreatment: Apply specified **bonding agent.**

C. General Placement: Place patching mortar by troweling toward edges of patch to force intimate contact with edge surfaces. For large patches, fill edges first and then work toward center, always troweling toward edges of patch. At fully exposed reinforcing bars, force patching mortar to fill space behind bars by compacting with trowel from sides of bars.

D. Consolidation: After each lift is placed, consolidate material and screed surface.

E. Finishing: Allow surfaces of lifts that are to remain exposed to become firm and then finish to a surface matching adjacent concrete.

F. Curing: Wet-cure cementitious patching materials, including polymer-modified cementitious patching materials, for not less than seven days by water-fog spray or water-saturated absorptive cover.

## 3.7 INSTALLATION OF DRY-PACK-MORTAR

A. Place dry-pack mortar into cavity by hand, and compact tightly into place. Do not place more material at a time than can be properly compacted. Continue placing and compacting until patch is approximately level with surrounding surface.

B. After cavity is filled and patch is compacted, trowel surface to match profile and finish of surrounding concrete.

C. Wet-cure patch for not less than seven days by water-fog spray or water-saturated absorptive cover.

## 3.8 PLACEMENT OF CONCRETE

A. Place concrete in accordance with **Section 033000 "Cast-in-Place Concrete"** and as specified in this article.

## 3.9 FLOOR-JOINT REPAIR

A. Cut out deteriorated concrete **and reconstruct sides of joint with patching mortar** as indicated on Drawings. Install joint filler in nonmoving floor joints where indicated and as specified in this article.

B. Depth: Install joint filler to a depth of at least **1 inch (25 mm)**. Use fine silica sand no more than 1/4 inch (6 mm) deep to close base of joint. Do not use sealant backer rods or compressible fillers below joint filler.

C. Top Surface: Install joint filler so that when cured, it is flush at top surface of adjacent concrete. If necessary, overfill joint and remove excess when filler has cured.

## 3.10 APPLICATION OF EPOXY CRACK-INJECTION MATERIALS

A. Clean cracks with oil-free compressed air or low-pressure water to remove loose particles.

B. Clean areas to receive capping adhesive of oil, dirt, and other substances that would interfere with bond.

C. Place injection ports as recommended by epoxy manufacturer, spacing no farther apart than thickness of member being injected. Seal injection ports in place with capping adhesive.

D. Seal cracks at exposed surfaces with a ribbon of capping adhesive at least 1/4 inch (6 mm) thick by 1 inch (25 mm) wider than crack.

E. Inject cracks wider than 0.003 inch (0.075 mm) to a depth of 8 inches (200 mm).

F. Inject epoxy adhesive, beginning at widest part of crack and working toward narrower parts. Inject adhesive into ports to refusal, capping adjacent ports when they extrude epoxy. Cap injected ports and inject through adjacent ports until crack is filled.

G. After epoxy adhesive has set, remove injection ports and grind surfaces smooth.

## 3.11 APPLICATION OF CORROSION-INHIBITING MATERIALS

A. Apply by brush, roller, or airless spray in two coats at manufacturer's recommended application rate. Remove film of excess treatment by high-pressure washing before patching treated concrete **or applying a sealer**.

## 3.12 FIELD QUALITY CONTROL

A. Architect/Engineer with perform field site inspections.

B. Tests and Inspections:

1. Epoxy Crack Injection: Keep epoxy cracks exposed for inspection of proper installation.
   a. Refill cracks with epoxy mortar, where exposed and discovered during inspection, and in need of treatment.

C. Product will be considered defective if it does not pass inspections.

D. Prepare and submit inspection reports.

END OF SECTION 030130

SECTION 031000 - CONCRETE FORMING AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Form-facing material for cast-in-place concrete.
2. Shoring, bracing, and anchoring.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each of the following:
1. Concealed surface form-facing material.
2. Form ties.
3. Waterstops.
4. Form-release agent.

B. Shop Drawings: Prepared by, and signed and sealed by, a qualified professional engineer responsible for their preparation, detailing fabrication, assembly, and support of forms.

1. For exposed vertical concrete walls, indicate dimensions and form tie locations.
2. Indicate dimension and locations of construction and movement joints required to construct the structure in accordance with ACI 301 (ACI 301M).

a. Location of construction joints is subject to approval of the Architect.

3. Indicate location of waterstops.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Minutes of preinstallation conference.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Concrete Formwork: Design, engineer, erect, shore, brace, and maintain formwork, shores, and reshores in accordance with ACI 301 (ACI 301M), to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads, so that resulting concrete conforms to the required shapes, lines, and dimensions.

1. Design wood panel forms in accordance with APA's "Concrete Forming Design/Construction Guide."
2. Design formwork to limit deflection of form-facing material to 1/240 of center-to-center spacing of supports.

a. For architectural concrete specified in Section 033300 "Architectural Concrete," limit deflection of form-facing material, studs, and walers to 0.0025 times their respective clear spans (L/400).

2.2 FORM-FACING MATERIALS

A. As-Cast Surface Form-Facing Material:

1. Provide continuous, true, and smooth concrete surfaces.
2. Furnish in largest practicable sizes to minimize number of joints.
3. Acceptable Materials: As required to comply with Surface Finish designations specified in Section 033000 "Cast-In-Place Concrete, and as follows:
   a. Exterior-grade plywood panels, suitable for concrete forms, complying with DOC PS 1, and as follows:

      1) APA HDO (high-density overlay).
      2) APA MDO (medium-density overlay); mill-release agent treated and edge sealed.
      3) APA Structural 1 Plyform, B-B or better; mill oiled and edge sealed.
      4) APA Plyform Class I, B-B or better; mill oiled and edge sealed.

B. Concealed Surface Form-Facing Material: Lumber, plywood, metal, plastic, or another approved material.

1. Provide lumber dressed on at least two edges and one side for tight fit.

2.3 WATERSTOPS

A. Flexible Rubber Waterstops: U.S. Army Corps of Engineers CRD-C 513, with factory-installed metal eyelets, for embedding in concrete to prevent passage of fluids through joints, with factory fabricate corners, intersections, and directional changes.

1. <u>Manufacturers:</u> Subject to compliance with requirements, provide products by the following:

a. Williams Products, Inc.
2. Profile: Flat dumbbell with center bulb.
3. Dimensions: 4 inches by 3/16 inch thick (100 mm by 4.8 mm thick); nontapered.

B. Self-Expanding Rubber Strip Waterstops: Manufactured rectangular or trapezoidal strip, bentonite-free hydrophilic polymer-modified chloroprene rubber, for adhesive bonding to concrete, 3/8 by 3/4 inch (10 by 19 mm).

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

a. GCP Applied Technologies Inc.
b. OCM, Inc.
c. Sika Corporation.

2.4 RELATED MATERIALS

A. Form-Release Agent: Commercially formulated form-release agent that does not bond with, stain, or adversely affect concrete surfaces and does not impair subsequent treatments of concrete surfaces.

1. Formulate form-release agent with rust inhibitor for steel form-facing materials.
2. Form release agent for form liners shall be acceptable to form liner manufacturer.

B. Form Ties: Factory-fabricated, removable or snap-off, glass-fiber-reinforced plastic or metal form ties designed to resist lateral pressure of fresh concrete on forms and to prevent spalling of concrete on removal.
1. Furnish ties with integral water-barrier plates to walls indicated to receive dampproofing or waterproofing.

PART 3 - EXECUTION

3.1 INSTALLATION OF FORMWORK

A. Comply with ACI 301 (ACI 301M).

B. Construct formwork, so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117 (ACI 117M) and to comply with the Surface Finish designations specified in Section 033000 "Cast-In-Place Concrete".

C. Limit concrete surface irregularities as follows:

1. Surface Finish-1.0: ACI 117 Class D, 1 inch (25 mm).
2. Surface Finish-2.0: ACI 117 Class B, 1/4 inch (6 mm).
3. Surface Finish-3.0: ACI 117 Class A, 1/8 inch (3.0 mm).

D. Construct forms tight enough to prevent loss of concrete mortar.

1. Minimize joints.

2. Exposed Concrete: Symmetrically align joints in forms.

E. Construct removable forms for easy removal without hammering or prying against concrete surfaces.

1. Provide crush or wrecking plates where stripping may damage cast-concrete surfaces.
2. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
3. Install keyways, reglets, recesses, and other accessories, for easy removal.

F. Do not use rust-stained, steel, form-facing material.

G. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces.

1. Provide and secure units to support screed strips.
2. Use strike-off templates or compacting-type screeds.

H. Provide temporary openings for cleanouts and inspection ports where interior area of formwork is inaccessible.

1. Close openings with panels tightly fitted to forms and securely braced to prevent loss of concrete mortar.
2. Locate temporary openings in forms at inconspicuous locations.

I. Chamfer exterior corners and edges of permanently exposed concrete.

J. At construction joints, overlap forms onto previously placed concrete not less than 12 inches (305 mm).

K. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work.

1. Determine sizes and locations from trades providing such items.
2. Obtain written approval of Architect prior to forming openings not indicated on Drawings.

L. Construction and Movement Joints:

1. Construct joints true to line with faces perpendicular to surface plane of concrete.

2. Locate ports and openings in bottom of vertical forms, in inconspicuous location, to allow flushing water to drain.
3. Close temporary ports and openings with tight-fitting panels, flush with inside face of form, and neatly fitted, so joints will not be apparent in exposed concrete surfaces.

M. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.

N. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.

O. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

## 3.2 INSTALLATION OF EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining work that is attached to or supported by cast-in-place concrete.

1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor rods, accurately located, to elevations required and complying with tolerances in Section 7.5 of AISC 303.
3. Install reglets to receive waterproofing and to receive through-wall flashings in outer face of concrete frame at exterior walls, where flashing is shown at lintels, shelf angles, and other conditions.
4. Install dovetail anchor slots in concrete structures, as indicated on Drawings.
5. Clean embedded items immediately prior to concrete placement.

## 3.3 INSTALLATION OF WATERSTOPS

A. Flexible Waterstops: Install in construction joints and at other joints indicated to form a continuous diaphragm.

1. Install in longest lengths practicable.
2. Locate waterstops in center of joint unless otherwise indicated on Drawings.
3. Allow clearance between waterstop and reinforcing steel of not less than 2 times the largest concrete aggregate size specified in Section 033000 "Cast-In-Place Concrete."
4. Secure waterstops in correct position at 12 inches (305 mm) on center.
5. Field fabricate joints in accordance with manufacturer's instructions using heat welding.

    a. Miter corners, intersections, and directional changes in waterstops.
    b. Align center bulbs.

6. Clean waterstops immediately prior to placement of concrete.
7. Support and protect exposed waterstops during progress of the Work.

B. Self-Expanding Strip Waterstops: Install in construction joints and at other locations indicated on Drawings, according to manufacturer's written instructions, by adhesive bonding, mechanically fastening, and firmly pressing into place.

1. Install in longest lengths practicable.
2. Locate waterstops in center of joint unless otherwise indicated on Drawings.
3. Protect exposed waterstops during progress of the Work.

## 3.4 FIELD QUALITY CONTROL

A. Architect/Engineer with perform field site inspections.

B. Tests and Inspections: A/E to perform inspections and submit reports.

C. Inspections:

1. Inspect formwork for shape, location, and dimensions of the concrete member being formed.
2. Inspect insulating concrete forms for shape, location, and dimensions of the concrete member being formed.

END OF SECTION 031000

SECTION 032000 - CONCRETE REINFORCING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Steel reinforcement bars.

B. Welded-wire reinforcement. Related Requirements:

1. Section 321313 "Concrete Paving" for reinforcing related to concrete pavement and walks.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review the following:

a. Special inspection and testing and inspecting agency procedures for field quality control.
b. Construction contraction and isolation joints.
c. Steel-reinforcement installation.

1.3 ACTION SUBMITTALS

A. Product Data: For the following:

1. Each type of steel reinforcement.
2. Bar supports.

B. Shop Drawings: Comply with ACI SP-066:

1. Include placing drawings that detail fabrication, bending, and placement.
2. Include bar sizes, lengths, materials, grades, bar schedules, stirrup spacing, bent bar diagrams, bar arrangement, location of splices, lengths of lap splices, details of mechanical splice couplers, details of welding splices, tie spacing, hoop spacing, and supports for concrete reinforcement.

C. Construction Joint Layout: Indicate proposed construction joints required to build the structure.

1. Location of construction joints is subject to approval of Architect.

1.4 INFORMATIONAL SUBMITTALS

A. Welding certificates.

1. Reinforcement to Be Welded: Welding procedure specification in accordance with AWS D1.4/D1.4M.

B. Material Certificates: For each of the following, signed by manufacturers:

1. Epoxy-Coated Reinforcement: CRSI's "Epoxy Coating Plant Certification."

C. Material Test Reports: For the following, from a qualified testing agency:

1. Steel Reinforcement:

a. For reinforcement to be welded, mill test analysis for chemical composition and carbon equivalent of the steel in accordance with ASTM A706/A706M.

2. Mechanical splice couplers.

D. Field quality-control reports.

E. Minutes of preinstallation conference.

## 1.5 QUALITY ASSURANCE

A. On site inspections by Architect/Engineer.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Steel Reinforcement: Deliver, store, and handle steel reinforcement to prevent bending and damage.

1. Store reinforcement to avoid contact with earth.

# PART 2 - PRODUCTS

## 2.1 STEEL REINFORCEMENT

A. Reinforcing Bars: ASTM A615/A615M, Grade 60 (Grade 420), deformed.

B. Plain-Steel Welded-Wire Reinforcement: ASTM A1064/A1064M, plain, fabricated from as-drawn steel wire into flat sheets.

## 2.2 REINFORCEMENT ACCESSORIES

A. Joint Dowel Bars: ASTM A615/A615M, Grade 60 (Grade 420), plain-steel bars, cut true to length with ends square and free of burrs.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded-wire reinforcement in place.

1. Manufacture bar supports from steel wire, plastic, or precast concrete in accordance with CRSI's "Manual of Standard Practice," of greater compressive strength than concrete and as follows:

    a. For concrete surfaces exposed to view, where legs of wire bar supports contact forms, use CRSI Class 1 plastic-protected steel wire, all-plastic bar supports, or CRSI Class 2 stainless steel bar supports.

C. Steel Tie Wire: ASTM A1064/A1064M, annealed steel, not less than 0.0508 inch (1.2908 mm) in diameter.

D. Finish: Plain.

## 2.3 FABRICATING REINFORCEMENT

A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Protection of In-Place Conditions:

1. Do not cut or puncture vapor retarder.
2. Repair damage and reseal vapor retarder before placing concrete.

B. Clean reinforcement of loose rust and mill scale, earth, ice, and other foreign materials that reduce bond to concrete.

## 3.2 INSTALLATION OF STEEL REINFORCEMENT

A. Comply with CRSI's "Manual of Standard Practice" for placing and supporting reinforcement.

B. Accurately position, support, and secure reinforcement against displacement.

1. Locate and support reinforcement with bar supports to maintain minimum concrete cover.
2. Do not tack weld crossing reinforcing bars.

C. Preserve clearance between bars of not less than 1 inch (25 mm), not less than one bar diameter, or not less than 1-1/3 times size of large aggregate, whichever is greater.

D. Provide concrete coverage in accordance with ACI 318 (ACI 318M).

E. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.

F. Splices: Lap splices as indicated on Drawings.

1. Bars indicated to be continuous, and all vertical bars to be lapped not less than 36 bar diameters at splices, or 24 inches (610 mm), whichever is greater.
2. Stagger splices in accordance with ACI 318 (ACI 318M).

3. Weld reinforcing bars in accordance with AWS D1.4/D 1.4M, where indicated on Drawings.

G. Install welded-wire reinforcement in longest practicable lengths.

1. Support welded-wire reinforcement in accordance with CRSI "Manual of Standard Practice."

a. For reinforcement less than W4.0 or D4.0, continuous support spacing to not exceed 12 inches (305 mm).

2. Lap edges and ends of adjoining sheets at least one wire spacing plus 3 inches (50 mm) for plain wire and 8 inches (200 mm) for deformed wire.
3. Offset laps of adjoining sheet widths to prevent continuous laps in either direction.
4. Lace overlaps with wire.

## 3.3 JOINTS

A. Construction Joints: Install so strength and appearance of concrete are not impaired, at locations indicated or as approved by Architect.

1. Place joints perpendicular to main reinforcement.
2. Continue reinforcement across construction joints unless otherwise indicated.
3. Do not continue reinforcement through sides of strip placements of floors and slabs.

## 3.4 INSTALLATION TOLERANCES

A. Comply with ACI 117 (ACI 117M).

## 3.5 FIELD QUALITY CONTROL

A. Architect/Engineer with perform field site inspections.

B. Inspections:

1. Steel-reinforcement placement.

END OF SECTION 032000

SECTION 033000 - CAST-IN-PLACE CONCRETE

PART 1 - GENERAL

1.1 SUMMARY

A. All products and construction material shall comply with the Buy American, Build America requirements enacted as part of the Infrastructure Investment and Jobs Act on Nov. 15, 2021. This ACT established a domestic content procurement preference for all Federal financial assistance obligated for infrastructure projects after May 14, 2022. See *https;//www.commerce.gov/oam/build-america-buy-america*.

B. Section Includes:

1. Concrete standards.
2. Concrete materials.
3. Admixtures.
4. Vapor retarders.
5. Curing materials.
6. Accessories.
7. Repair materials.
8. Concrete mixture materials.
9. Concrete mixture class types.
10. Concrete mixing.

C. Related Requirements:

1. Section 031000 "Concrete Forming and Accessories" for form-facing materials, and waterstops.
2. Section 032000 "Concrete Reinforcing" for steel reinforcing bars and welded-wire reinforcement.
3. Section 312000 "Earth Moving" for drainage fill under slabs-on-ground.
4. Section 321313 "Concrete Paving" for concrete pavement and walks.

1.2 DEFINITIONS

A. Cementitious Materials: Portland cement or blended hydraulic cement alone or in combination with one or more of the following:

1. Fly ash, slag cement, other pozzolans, and silica fume; materials subject to compliance with requirements.

B. Water/Cementitious Materials (w/cm) Ratio: The ratio by weight of mixing water to cementitious materials.

## 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Require representatives of each entity directly concerned with cast-in-place concrete to attend, including the following:

   a. Contractor's superintendent.
   b. Independent testing agency responsible for inspections and acceptance testing of concrete at Project site.
   c. Ready-mix concrete manufacturer.
   d. Concrete Subcontractor.

2. Review the following:

   a. Special inspection and testing and inspecting agency procedures for field quality control.
   b. Construction joints, control joints, isolation joints, and joint-filler strips.
   c. Semirigid joint fillers.
   d. Vapor-retarder installation.
   e. Anchor rod and anchorage device installation tolerances.
   f. Concrete finishes and finishing.
   g. Curing procedures.
   h. Forms and form-removal limitations.
   i. Methods for achieving specified floor and slab flatness and levelness.
   j. Floor and slab flatness and levelness measurements.
   k. Concrete repair procedures.
   l. Concrete protection.
   m. Initial curing of standard-cured and field curing of field-cured test cylinders (ASTM C31/C31M.)
   n. Distribution of test reports.

## 1.4 ACTION SUBMITTALS

A. All products and construction materials shall comply with the Buy American, Build America requirements enacted as part of the Infrastructure Investment and Jobs Act on Nov. 15, 2021. The ACT established a domestic content procurement preference for all Federal financial assistance obligated for infrastructure projects after May 14, 2022. See *https;//www.commerce.gov/oam/build-america-buy-america*. All submittals shall demonstrate compliance to BABAA. If the information is not included in the submittal, the submittal will be rejected and returned.

B. Product Data:

1. Portland cement.
2. Blended hydraulic cement.
3. Fly ash.
4. Slag cement.
5. Natural or other pozzolans.
6. Aggregates.

7. Admixtures:

    a. Include limitations of use. Admixtures that do not comply with reference ASTM International requirements must be submitted with test data for approval.

8. Vapor retarders.
9. Curing materials.
10. Joint fillers.
11. Repair materials.

C. Design Mixtures: For each concrete mixture, include the following:

1. Mixture identification.
2. Compressive strength at 28 days or other age as specified.
3. Compressive strength required at stages of construction.
4. Durability exposure classes for Exposure Categories F, S, W, and C.
5. Maximum w/cm ratio.
6. Slump.
7. Air content.
8. Nominal maximum aggregate size.
9. Intended placement method.
10. Submit adjustments to design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant changes.

D. Shop Drawings:

1. Construction Joint Layout: Indicate proposed construction joints required to construct the structure.

    a. Location of construction joints is subject to approval of the Engineer.

E. Concrete Schedule: For each location of each class of concrete indicated in "Concrete Mixture Class Types" Article, including the following:

1. Concrete class designation.
2. Location within Project.
3. Exposure class designation.
4. Formed surface finish designation and final finish.
5. Final finish for floors.
6. Floor treatment, if any.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For the following:

1. Installer: Include copies of applicable ACI certificates.
2. Testing Agency: Include documentation indicating compliance with ASTM E329 or ASTM C1077 and copies of applicable ACI certificates for testing technicians or ACI Concrete Construction Special Inspector - MH, ASCC.

B. Material Certificates: For each of the following:

1. Cementitious materials.
2. Admixtures.
3. Bonding agents.
4. Adhesives.
5. Vapor retarders.
6. Semirigid joint filler.
7. Joint-filler strips.
8. Repair materials.

C. Material Test Reports: For the following:

1. Portland cement.
2. Blended hydraulic cement.
3. Performance-based hydraulic cement.
4. Fly ash.
5. Slag cement.
6. Silica fume.
7. Natural or other pozzolans.
8. Aggregates.
9. Admixtures.

D. Floor surface flatness and levelness measurements report, indicating compliance with specified tolerances in accordance with ACI 117 and in compliance with ASTM E1155 (ASTM E1155M).

E. Research Reports:

1. For concrete admixtures in accordance with ICC's Acceptance Criteria AC198.
2. For sheet vapor retarder/termite barrier, showing compliance with ICC's Acceptance Criteria AC380.

F. Preconstruction Test Reports: For each mix design.

G. Field quality-control reports.

H. Minutes of preinstallation conference.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified Installer who employs Project personnel qualified as an ACI-certified Concrete Flatwork Associate and Concrete Flatwork Finisher and a supervisor who is a certified ACI Advanced Concrete Flatwork Finisher/Technician or an ACI Concrete Flatwork Finisher with experience installing and finishing concrete.

1. Post-Installed Concrete Anchors Installers: ACI-certified Adhesive Anchor Installer.

B. Ready-Mixed Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C94/C94M requirements for production facilities and equipment.

## 1.7 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage a qualified testing agency to perform preconstruction testing on each concrete mixture.

1. Include the following information in each test report:

a. Admixture dosage rates.
b. Slump.
c. Air content.
d. Seven-day compressive strength.
e. 28-day compressive strength.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Comply with ASTM C94/C94M and ACI 301 (ACI 301M).

## 1.9 FIELD CONDITIONS

A. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and ACI 305.1 (ACI 305.1M), and as follows:

1. Maintain concrete temperature at time of discharge to not exceed 95 deg F (35 deg C).
2. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.

## 1.10 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to furnish replacement sheet vapor retarder/termite barrier material and accessories for sheet vapor retarder/ termite barrier and accessories that do not comply with requirements or that fail to resist penetration by termites within specified warranty period.

1. Warranty Period: 10 years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 CONCRETE STANDARDS

A. ACI Publications: Comply with ACI 301 (ACI 301M) unless modified by requirements in the Contract Documents.

## 2.2 CONCRETE MATERIALS

A. Source Limitations:

1. Obtain all concrete mixtures from a single ready-mixed concrete manufacturer for entire Project.
2. Obtain each type of admixture from single source from single manufacturer.

B. Cementitious Materials:

1. Portland Cement: ASTM C150/C150M, Type I or Type II, gray.
2. Blended Hydraulic Cement: ASTM C595/C595M, Type IL, portland-limestone cement.
3. Pozzolans: ASTM C618, Class C, F, or N.
4. Slag Cement: ASTM C989/C989M, Grade 100 or 120.
5. Ground Glass Pozzolan: ASTM C1866/C1866M, Type GS or GE.

C. Normal-Weight Aggregates:
1. Fine Aggregate: ASTM C33/C33M.
2. Alkali-Silica Reaction: Comply with one of the following for each aggregate used:

a. Expansion Result of Aggregate: Not more than 0.04 percent at one year when tested in accordance with ASTM C1293.

## 2.3 ADMIXTURES

A. Air-Entraining Admixture: ASTM C260/C260M.

B. Chemical Admixtures: Do not use calcium chloride or admixtures containing calcium chloride.

C. Mixing Water for Concrete Mixtures and Water Used to Make Ice: ASTM C1602/C1602M. Include documentation of compliance with limits for alkalis, sulfates, chlorides, or solids content of mixing water from Table 2 in ASTM C1602/C1602M.

## 2.4 VAPOR RETARDERS

A. Sheet Vapor Retarder/Termite Barrier: ASTM E1745, Class A, except with maximum water-vapor permeance of 0.03 perms; complying with ICC Acceptance Criteria AC380. Include manufacturer's recommended adhesive or pressure-sensitive tape.

1. Low-Temperature Flexibility: Pass at minus 15 deg F (minus 26 deg C); ASTM D146/D146M.
2. Puncture Resistance: 224 lbf (996 N) minimum; ASTM E154/E154M.
3. Water Absorption: 0.1 percent weight-gain maximum after 48-hour immersion at 70 deg F (21 deg C); ASTM D570.
4. Hydrostatic-Head Resistance: 231 ft. (70 m) minimum; ASTM D5385/D5385M.

## 2.5 CURING MATERIALS

A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry.

C. Moisture-Retaining Cover: ASTM C171, polyethylene film burlap-polyethylene sheet.

1. Color:
   a. Ambient Temperature between 50 and 85 deg F (10 and 29 deg C): Any color.
   b. Ambient Temperature Above 85 deg F (29 deg C): White.

D. Curing Paper: 8 ft. (2438 mm) wide paper, consisting of two layers of fibered kraft paper laminated with double coating of asphalt.

E. Water: Potable water that does not cause staining of the surface.

## 2.6 ACCESSORIES

A. Bonding Agent: ASTM C1059/C1059M, Type II, nonredispersible, acrylic emulsion or styrene butadiene.

## 2.7 REPAIR MATERIALS

A. Repair Underlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/8 inch (3 mm) and that can be feathered at edges to match adjacent floor elevations.

1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
2. Primer: Product of underlayment manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand, as recommended by underlayment manufacturer.
4. Compressive Strength: Not less than 4100 psi (29 MPa) at 28 days when tested in accordance with ASTM C109/C109M.

B. Repair Overlayment: Cement-based, polymer-modified, self-leveling product that can be applied in thicknesses from 1/4 inch (6 mm) and that can be filled in over a scarified surface to match adjacent floor elevations.

1. Cement Binder: ASTM C150/C150M portland cement or hydraulic or blended hydraulic cement, as defined in ASTM C219.
2. Primer: Product of topping manufacturer recommended for substrate, conditions, and application.
3. Aggregate: Well-graded, washed gravel, 1/8 to 1/4 inch (3 to 6 mm) or coarse sand as recommended by topping manufacturer.

4. Compressive Strength: Not less than [**5000 psi (34.5 MPa)**] at 28 days when tested in accordance with ASTM C109/C109M.

2.8 CONCRETE MIXTURE MATERIALS

A. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, in accordance with ACI 301 (ACI 301M).

1. Use a qualified testing agency for preparing and reporting proposed mixture designs, based on laboratory trial mixtures.

B. Admixtures: Use admixtures in accordance with manufacturer's written instructions.

2.9 CONCRETE MIXTURE CLASS TYPES

A. Class A: Normal-weight concrete used for footings.

1. Exposure Class: ACI 318 (ACI 318M) Class F1, Class S0, Class W0, Class C1.
2. Minimum Compressive Strength: 3000 psi (20.7 MPa) at 28 days.

B. Class C: Normal-weight concrete used for interior slabs-on-ground.

1. Exposure Class: ACI 318 (ACI 318M) Class F0, Class S0, Class W0, Class C0.
2. Minimum Compressive Strength: 4000 psi (27.6 MPa) at 28 days.
3. Maximum w/cm Ratio : 0.50.
4. Limit water-soluble, chloride-ion content in hardened concrete to 1.00 percent by weight of cement.

2.10 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete in accordance with ASTM C94/C94M and furnish delivery ticket.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions:

1. Before placing concrete, verify that installation of concrete forms, accessories, reinforcement, and embedded items is complete and that required inspections have been performed.
2. Do not proceed until unsatisfactory conditions have been corrected.

## 3.2 PREPARATION

A. Provide reasonable auxiliary services to accommodate field testing and inspections, acceptable to testing agency, including the following:

1. Daily access to the Work.
2. Incidental labor and facilities necessary to facilitate tests and inspections.
3. Secure space for storage, initial curing, and field curing of test samples, including source of water and continuous electrical power at Project site during site curing period for test samples.
4. Security and protection for test samples and for testing and inspection equipment at Project site.

## 3.3 TOLERANCES

A. Comply with ACI 117 (ACI 117M).

## 3.4 INSTALLATION OF EMBEDDED ITEMS

A. Place and secure anchorage devices and other embedded items required for adjoining Work that is attached to or supported by cast-in-place concrete.

1. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

## 3.5 INSTALLATION OF VAPOR RETARDERS

A. Sheet Vapor Retarders: Place, protect, and repair sheet vapor retarder in accordance with ASTM E1643 and manufacturer's written instructions.

1. Install vapor retarder with longest dimension parallel with direction of concrete pour.
2. Face laps away from exposed direction of concrete pour.
3. Lap vapor retarder over footings and grade beams not less than 6 inches (150 mm), sealing vapor retarder to concrete.
4. Lap joints 6 inches (150 mm) and seal with manufacturer's recommended tape.
5. Seal penetrations in accordance with vapor retarder manufacturer's instructions.
6. Protect vapor retarder during placement of reinforcement and concrete.

    a. Repair damaged areas by patching with vapor retarder material, overlapping damages area by 6 inches (150 mm) on all sides and sealing to vapor retarder.

## 3.6 INSTALLATION OF CAST-IN-PLACE CONCRETE

A. Before placing concrete, verify that installation of formwork, reinforcement, embedded items, and vapor retarder is complete and that required inspections are completed.

1. Immediately prior to concrete placement, inspect vapor retarder for damage and deficient installation, and repair defective areas.

2. Provide continuous inspection of vapor retarder during concrete placement and make necessary repairs to damaged areas as Work progresses.

B. Notify Architect and testing and inspection agencies 24 hours prior to commencement of concrete placement.

C. Water addition in transit or at the Project site must be in accordance with ASTM C94/C94M and must not exceed the permitted amount indicated on the concrete delivery ticket.

D. Deposit concrete continuously in one layer or in horizontal layers of such thickness that no new concrete is placed on concrete that has hardened enough to cause seams or planes of weakness.

1. If a section cannot be placed continuously, provide construction joints as indicated.
2. Deposit concrete to avoid segregation.
3. Deposit concrete in horizontal layers of depth not to exceed formwork design pressures and in a manner to avoid inclined construction joints.
4. Consolidate placed concrete with mechanical vibrating equipment in accordance with ACI 301 (ACI 301M).

a. Do not use vibrators to transport concrete inside forms.
b. Insert and withdraw vibrators vertically at uniformly spaced locations to rapidly penetrate placed layer and at least 6 inches (150 mm) into preceding layer.
c. Do not insert vibrators into lower layers of concrete that have begun to lose plasticity.
d. At each insertion, limit duration of vibration to time necessary to consolidate concrete, and complete embedment of reinforcement and other embedded items without causing mixture constituents to segregate.

E. Deposit and consolidate concrete for floors and slabs in a continuous operation, within limits of construction joints, until placement of a panel or section is complete.

1. Do not place concrete floors and slabs in a checkerboard sequence.
2. Consolidate concrete during placement operations, so concrete is thoroughly worked around reinforcement and other embedded items and into corners.
3. Maintain reinforcement in position on chairs during concrete placement.
4. Screed slab surfaces with a straightedge and strike off to correct elevations.
5. Level concrete, cut high areas, and fill low areas.
6. Slope surfaces uniformly to drains where required.
7. Begin initial floating using bull floats or darbies to form a uniform and open-textured surface plane, before excess bleedwater appears on the surface.
8. Do not further disturb slab surfaces before starting finishing operations.

## 3.7 INSTALLATION OF JOINTS

A. Construct joints true to line, with faces perpendicular to surface plane of concrete.

B. Construction Joints: Coordinate with floor slab pattern and concrete placement sequence.

1. Install so strength and appearance of concrete are not impaired, at locations indicated on Drawings or as approved by Architect.

2. Place joints perpendicular to main reinforcement.

    a. Continue reinforcement across construction joints unless otherwise indicated.

3. Locate joints for beams, slabs, joists, and girders at third points of spans. Offset joints in girders a minimum distance of twice the beam width from a beam-girder intersection.
4. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Control Joints in Slabs-on-Ground: Form weakened-plane control joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of concrete thickness as follows:

1. Sawed Joints: Form control joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch (3-mm-) wide joints into concrete when cutting action does not tear, abrade, or otherwise damage surface and before concrete develops random cracks.

D. Isolation Joints in Slabs-on-Ground: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.

1. Terminate full-width joint-filler strips not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface, where joint sealants, specified in Section 079200 "Joint Sealants," are indicated.

## 3.8 APPLICATION OF FINISHING FLOORS AND SLABS

A. Float Finish:

1. When bleedwater sheen has disappeared and concrete surface has stiffened sufficiently to permit operation of specific float apparatus, consolidate concrete surface with power-driven floats or by hand floating if area is small or inaccessible to power-driven floats.
2. Repeat float passes and restraightening until surface is left with a uniform, smooth, granular texture and complies with ACI 117 (ACI A117M) tolerances for conventional concrete.
3. Apply float finish to surfaces to receive trowel finish.

B. Trowel Finish:

1. After applying float finish, apply first troweling and consolidate concrete by hand or power-driven trowel.
2. Continue troweling passes and restraighten until surface is free of trowel marks and uniform in texture and appearance.
3. Grind smooth any surface defects that would telegraph through applied coatings or floor coverings.
4. Do not add water to concrete surface. Use of an approved finishing aid is acceptable.
5. Do not apply troweled finish to concrete, which has a total air content greater than 3 percent.

6. Apply a trowel finish to surfaces exposed to view or to be covered with resilient flooring, carpet, ceramic or quarry tile set over a cleavage membrane, paint, or another thin-film-finish coating system.
7. Finish surfaces to the following tolerances, in accordance with ASTM E1155 (ASTM E1155M), for a randomly trafficked floor surface:

    a. Slabs on Ground:

        1) Specified overall values of flatness, $F_F$ 25; and of levelness, $F_L$ 20; with minimum local values of flatness, $F_F$ 17; and of levelness, $F_L$ 15.

C. Trowel and Fine-Broom Finish: First apply a trowel finish to surfaces where ceramic or quarry tile is to be installed by either thickset or thinset method. While concrete is still plastic, slightly scarify surface with a fine broom perpendicular to main traffic route.

1. Coordinate required final finish with Architect before application.
2. Comply with flatness and levelness tolerances for trowel-finished floor surfaces.

## 3.9 INSTALLATION OF MISCELLANEOUS CONCRETE ITEMS

A. Filling in:

1. Fill in holes and openings left in concrete structures after Work of other trades is in place unless otherwise indicated.
2. Mix, place, and cure concrete, as specified, to match color and texture with in-place construction exposed to view.
3. Provide other miscellaneous concrete filling indicated or required to complete the Work.

## 3.10 APPLICATION OF CONCRETE CURING

A. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
1. Maintain moisture loss no more than 0.2 lb/sq. ft. x h (1 kg/sq. m x h), calculated in accordance with ACI 305R, before and during finishing operations.

B. Curing Unformed Surfaces: Comply with ACI 308.1 (ACI 308.1M) as follows:

1. Begin curing after finishing concrete.
2. Interior Concrete Floors:

    a. Floors to Receive Floor Coverings Specified in Other Sections: Contractor has option of the following:

        1) Absorptive Cover: As soon as concrete has sufficient set to permit application without marring concrete surface, install prewetted absorptive cover over entire area of floor.

            a) Lap edges and ends of absorptive cover not less than 12 inches (300 mm).
            b) Maintain absorptive cover water saturated, and in place, for duration of curing period, but not less than seven days.

2) Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches (300 mm), and sealed by waterproof tape or adhesive.

a) Immediately repair any holes or tears during curing period, using cover material and waterproof tape.
b) Cure for not less than seven days.

3) Ponding or Continuous Sprinkling of Water: Maintain concrete surfaces continuously wet for not less than seven days, utilizing one, or a combination of, the following not in cold weather:

a) Water.

## 3.11 INSTALLATION OF JOINT FILLING

A. Prepare, clean, and install joint filler in accordance with manufacturer's written instructions.

1. Defer joint filling until concrete has aged at least one month.

B. Remove dirt, debris, saw cuttings, curing compounds, and sealers from joints; leave contact faces of joints clean and dry.

C. Install semirigid joint filler full depth in saw-cut joints and at least 2 inches (50 mm) deep in formed joints.

D. Overfill joint, and trim joint filler flush with top of joint after hardening.

## 3.12 INSTALLATION OF CONCRETE SURFACE REPAIRS

A. Defective Concrete:

1. Repair and patch defective areas when approved by Architect.
2. Remove and replace concrete that cannot be repaired and patched to meet specification requirements.

B. Patching Mortar: Mix dry-pack patching mortar, consisting of 1 part portland cement to 2-1/2 parts fine aggregate passing a No. 16 (1.18-mm) sieve, using only enough water for handling and placing.

C. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks in excess of 0.01 inch (0.25 mm) spalls, air bubbles exceeding surface finish limits, honeycombs, rock pockets, fins and other projections on the surface exceeding surface finish limits, and stains and other discolorations that cannot be removed by cleaning.

1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than 1/2 inch (13 mm) in any dimension to solid concrete.

a. Limit cut depth to 3/4 inch (19 mm).

b. Make edges of cuts perpendicular to concrete surface.
c. Clean, dampen with water, and brush-coat holes and voids with bonding agent.
d. Fill and compact with patching mortar before bonding agent has dried.
e. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.

2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement, so that, when dry, patching mortar matches surrounding color.

   a. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching.
   b. Compact mortar in place and match surrounding surface.

3. Repair defects on concealed formed surfaces that will affect concrete's durability and structural performance, as determined by Architect.

D. Repairing Unformed Surfaces:

1. Test unformed surfaces, such as floors and slabs, for finish, and verify surface tolerances specified for each surface.

   a. Correct low and high areas.
   b. Test surfaces sloped to drain for trueness of slope and smoothness; use a sloped template.

2. Repair finished surfaces containing surface defects, including spalls, popouts, honeycombs, rock pockets, crazing, and cracks in excess of 0.01 inch (0.25 mm) wide or that penetrate to reinforcement or completely through unreinforced sections regardless of width.
3. After concrete has cured at least 14 days, correct high areas by grinding.
4. Correct localized low areas during, or immediately after, completing surface-finishing operations by adding patching mortar.

   a. Finish repaired areas to blend into adjacent concrete.

5. Correct other low areas scheduled to receive floor coverings with a repair underlayment.

   a. Prepare, mix, and apply repair underlayment and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.
   b. Feather edges to match adjacent floor elevations.

6. Correct other low areas scheduled to remain exposed with repair topping.

   a. Cut out low areas to ensure a minimum repair topping depth of 1/4 inch (6 mm) to match adjacent floor elevations.
   b. Prepare, mix, and apply repair topping and primer in accordance with manufacturer's written instructions to produce a smooth, uniform, plane, and level surface.

7. Repair defective areas, except random cracks and single holes 1 inch (25 mm) or less in diameter, by cutting out and replacing with fresh concrete.

    a. Remove defective areas with clean, square cuts, and expose steel reinforcement with at least a 3/4-inch (19-mm) clearance all around.
    b. Dampen concrete surfaces in contact with patching concrete and apply bonding agent.
    c. Mix patching concrete of same materials and mixture as original concrete, except without coarse aggregate.
    d. Place, compact, and finish to blend with adjacent finished concrete.
    e. Cure in same manner as adjacent concrete.

8. Repair random cracks and single holes 1 inch (25 mm) or less in diameter with patching mortar.

    a. Groove top of cracks and cut out holes to sound concrete, and clean off dust, dirt, and loose particles.
    b. Dampen cleaned concrete surfaces and apply bonding agent.
    c. Place patching mortar before bonding agent has dried.
    d. Compact patching mortar and finish to match adjacent concrete.
    e. Keep patched area continuously moist for at least 72 hours.

E. Perform structural repairs of concrete, subject to Architect's approval, using epoxy adhesive and patching mortar.

F. Repair materials and installation not specified above may be used, subject to Architect's approval.

## 3.13 FIELD QUALITY CONTROL

A. Inspections: Architect/Engineer to perform field inspections and quality control in placement of non-structural concrete slab over modifications due to renovation.

B. Measure floor and slab flatness and levelness in accordance with ASTM E1155 (ASTM E1155M) within 24 hours of completion of floor finishing and promptly report test results to Architect.

## 3.14 PROTECTION

A. Protect concrete surfaces as follows:

1. Protect from petroleum stains.
2. Prohibit use of pipe-cutting machinery over concrete surfaces.
3. Prohibit placement of steel items on concrete surfaces.
4. Prohibit use of acids or acidic detergents over concrete surfaces.

END OF SECTION 033000

SECTION 040110 - MASONRY CLEANING

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 cleaning the following:

1. Unit masonry surfaces.

1.3 DEFINITIONS

A. Medium-Pressure Spray: 400 to 800 psi (2750 to 5510 kPa); 4 to 6 gpm (0.25 to 0.4 L/s).

1.4 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at .

1. Review methods and procedures related to cleaning masonry including, but not limited to, the following:

a. Verify masonry-cleaning equipment and facilities needed to make progress and avoid delays.
b. Materials, material application, and sequencing.
c. Cleaning program.
d. Coordination with building occupants.

1.5 SEQUENCING AND SCHEDULING

A. Work Sequence: Perform masonry-cleaning work in the following sequence:

1. Remove plant growth.
2. Inspect for open mortar joints. Where repairs are required, delay further cleaning work until after repairs are completed, cured, and dried to prevent the intrusion of water and other cleaning materials into the wall.
3. Remove paint.
4. Clean masonry surfaces.
5. Where water repellents are to be used on or near masonry, delay application of these chemicals until after cleaning.

B. As scaffolding is removed, patch anchor holes used to attach scaffolding. Patch holes in masonry units according to masonry repair Sections. Patch holes in mortar joints according to masonry repointing Sections.

## 1.6 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include material descriptions and application instructions.
2. Include test data substantiating that products comply with requirements.

## 1.7 INFORMATIONAL SUBMITTALS

A. Qualification Data: For paint-remover manufacturer and chemical-cleaner manufacturer.

B. Preconstruction Test Reports: For cleaning materials and methods.

C. Cleaning program.

## 1.8 QUALITY ASSURANCE

A. Cleaning Program: Prepare a written cleaning program that describes cleaning process in detail, including materials, methods, and equipment to be used; protection of surrounding materials; and control of runoff during operations. Include provisions for supervising worker performance and preventing damage.

1. If materials and methods other than those indicated are proposed for any phase of cleaning work, add a written description of such materials and methods, including evidence of successful use on comparable projects and demonstrations to show their effectiveness for this Project.

B. Mockups: Prepare mockups of cleaning on existing surfaces to demonstrate aesthetic effects and to set quality standards for materials and execution.

1. Cleaning: Clean an area approximately 25 sq. ft. (2.3 sq. m) for each type of masonry and surface condition.

   a. Test cleaners and methods on samples of adjacent materials for possible adverse reactions. Do not test cleaners and methods known to have deleterious effect.
   b. Allow a waiting period of not less than seven days after completion of sample cleaning to permit a study of sample panels for negative reactions.

2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

## 1.9 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Engage one or more chemical-cleaner and paint-remover manufacturers to perform preconstruction testing on masonry surfaces.

1. Use test areas as indicated and representative of proposed materials and existing construction.
2. Propose changes to materials and methods to suit Project.

## 1.10 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit masonry-cleaning work to be performed according to product manufacturers' written instructions and specified requirements.

B. Clean masonry surfaces only when air temperature is 40 deg F (4 deg C) and above and is predicted to remain so for at least seven days after completion of cleaning.

# PART 2 - PRODUCTS

## 2.1 PAINT REMOVERS

A. Low-Odor, Solvent-Type Paste Paint Remover: Manufacturer's standard low-odor, water-rinsible, solvent-type paste, gel, or foamed emulsion formulation, for removing paint from masonry; containing no methanol or methylene chloride.

B. Covered, Solvent-Type Paste Paint Remover: Manufacturer's standard, low-odor, covered, water-rinsible, solvent-type paste or gel formulation, for removing paint coatings from masonry; containing no methanol or methylene chloride.

## 2.2 CLEANING MATERIALS

A. Water: Potable.

B. Hot Water: Water heated to a temperature of 140 to 160 deg F (60 to 71 deg C).

C. Detergent Solution, Job Mixed: Solution prepared by mixing 2 cups (0.5 L) of tetrasodium pyrophosphate (TSPP), 1/2 cup (125 mL) of laundry detergent, and 20 quarts (20 L) of hot water for every 5 gal. (20 L) of solution required.

D. Mold, Mildew, and Algae Remover, Job Mixed: Solution prepared by mixing 2 cups (0.5 L) of tetrasodium pyrophosphate (TSPP), 5 quarts (5 L) of 5 percent sodium hypochlorite (bleach), and 15 quarts (15 L) of hot water for every 5 gal. (20 L) of solution required.

E. Nonacidic Gel Cleaner: Manufacturer's standard gel formulation, with pH between 6 and 9, that contains detergents with chelating agents and is specifically formulated for cleaning masonry surfaces.

F. Nonacidic Liquid Cleaner: Manufacturer's standard mildly alkaline liquid cleaner formulated for removing mold, mildew, and other organic soiling from ordinary building materials, including polished stone, brick, aluminum, plastics, and wood.

## 2.3 ACCESSORY MATERIALS

A. Liquid Strippable Masking Agent: Manufacturer's standard liquid, film-forming, strippable masking material for protecting glass, metal, glazed masonry, and polished stone surfaces from damaging effects of acidic and alkaline masonry cleaners.

# PART 3 - EXECUTION

## 3.1 MASONRY-CLEANING SPECIALIST

## 3.2 PROTECTION

A. Comply with each manufacturer's written instructions for protecting building and other surfaces against damage from exposure to its products. Prevent paint removers and chemical cleaning solutions from coming into contact with people, motor vehicles, landscaping, buildings, and other surfaces that could be harmed by such contact.

1. Cover adjacent surfaces with materials that are proven to resist paint removers and chemical cleaners used unless products being used will not damage adjacent surfaces. Use protective materials that are waterproof and UV resistant. Apply masking agents according to manufacturer's written instructions. Do not apply liquid strippable masking agent to painted or porous surfaces. When no longer needed, promptly remove masking to prevent adhesive staining.
2. Do not apply chemical solutions during winds of enough force to spread them to unprotected surfaces.
3. Neutralize alkaline and acid wastes before disposal.
4. Dispose of runoff from operations by legal means and in a manner that prevents soil erosion, undermining of paving and foundations, damage to landscaping, and water penetration into building interiors.

B. Remove gutters and downspouts and associated hardware adjacent to immediate work area and store during masonry cleaning. Reinstall when masonry cleaning is complete.

1. Provide temporary rain drainage during work to direct water away from building.

## 3.3 CLEANING MASONRY, GENERAL

A. Cleaning Appearance Standard: Cleaned surfaces are to have a uniform appearance as viewed from 20 feet (6 m) away by Architect.

B. Proceed with cleaning in an orderly manner; work from top to bottom of each scaffold width and from one end of each elevation to the other. Ensure that dirty residues and rinse water do not wash over dry, cleaned surfaces.

C. Use only those cleaning methods indicated for each masonry material and location.

1. Brushes: Do not use wire brushes or brushes that are not resistant to chemical cleaner being used.
2. Spray Equipment: Use spray equipment that provides controlled application at volume and pressure indicated, measured at nozzle. Adjust pressure and volume to ensure that cleaning methods do not damage surfaces, including joints.

    a. Equip units with pressure gages.
    b. For chemical-cleaner spray application, use low-pressure tank or chemical pump suitable for chemical cleaner indicated, equipped with nozzle having a cone-shaped spray.
    c. For water-spray application, use fan-shaped spray that disperses water at an angle of 25 to 50 degrees.
    d. For high-pressure water-spray application, use fan-shaped spray that disperses water at an angle of at least 40 degrees.
    e. For heated water-spray application, use equipment capable of maintaining temperature between 140 and 160 deg F (60 and 71 deg C) at flow rates indicated.

D. Perform each cleaning method indicated in a manner that results in uniform coverage of all surfaces, including corners, moldings, and interstices, and that produces an even effect without streaking or damaging masonry surfaces. Keep wall wet below area being cleaned to prevent streaking from runoff.

E. Perform additional general cleaning, paint and stain removal, and spot cleaning of small areas that are noticeably different when viewed according to the "Cleaning Appearance Standard" Paragraph, so that cleaned surfaces blend smoothly into surrounding areas.

F. Water Application Methods:

1. Water-Soak Application: Soak masonry surfaces by applying water continuously and uniformly to limited area for time indicated. Apply water at low pressures and low volumes in multiple fine sprays using perforated hoses or multiple spray nozzles. Erect a protective enclosure constructed of polyethylene sheeting to cover area being sprayed.
2. Water-Spray Applications: Unless otherwise indicated, hold spray nozzle at least 6 inches (150 mm) from masonry surface and apply water in horizontal back-and-forth sweeping motion, overlapping previous strokes to produce uniform coverage.

G. After cleaning is complete, remove protection no longer required. Remove tape and adhesive marks.

## 3.4 PRELIMINARY CLEANING

A. Remove loose soil and plant debris from open joints to whatever depth they occur.

B. Preliminary Cleaning: Before beginning general cleaning, remove extraneous substances that are resistant to planned cleaning methods. Extraneous substances include paint, calking, asphalt, and tar.

1. Carefully remove heavy accumulations of rigid materials from masonry surface with sharp chisel. Do not scratch or chip masonry surface.

2. Remove paint and calking with alkaline paint remover.

    a. Comply with requirements in "Paint Removal" Article.
    b. Repeat application up to two times if needed.

3. Remove asphalt and tar with solvent-type paste paint remover.

    a. Comply with requirements in "Paint Removal" Article.
    b. Apply paint remover only to asphalt and tar by brush without prewetting.
    c. Allow paint remover to remain on surface for 10 to 30 minutes.
    d. Repeat application if needed.

## 3.5 CLEANING MASONRY

A. Cold-Water Soak:

1. Apply cold water by intermittent spraying to keep surface moist.
2. Use perforated hoses or other means that apply a fine water mist to entire surface being cleaned.
3. Apply water in cycles of five minutes on and 20 minutes off.
4. Continue spraying until surface encrustation has softened enough to permit its removal by water wash, as indicated by cleaning tests for 72 hours.
5. Remove soil and softened surface encrustation from surface with cold water applied by low-pressure spray.

B. Cold-Water Wash: Use cold water applied by medium-pressure spray.

C. Hot-Water Wash: Use hot water applied by medium -pressure spray.

D. Steam Cleaning: Apply steam at very low pressures not exceeding 30 psi (207 kPa). Remove dirt softened by steam with wood scrapers, stiff-nylon or -fiber brushes, or cold-water wash, as indicated by cleaning tests.

E. Detergent Cleaning:

1. Wet surface with cold water applied by low-pressure spray.
2. Scrub surface with detergent solution using medium-soft brushes until soil is thoroughly dislodged and can be removed by rinsing. Use small brushes to remove soil from mortar joints and crevices. Dip brush in solution often to ensure that adequate fresh detergent is used and that surface remains wet.
3. Rinse with cold water applied by medium-pressure spray to remove detergent solution and soil.
4. Repeat cleaning procedure above where required to produce cleaning effect established by mockup.

F. Mold, Mildew, and Algae Removal:

1. Wet surface with cold water applied by low-pressure spray.
2. Apply mold, mildew, and algae remover by brush or low-pressure spray.
3. Scrub surface with medium-soft brushes until mold, mildew, and algae are thoroughly dislodged and can be removed by rinsing. Use small brushes for mortar joints and

crevices. Dip brush in mold, mildew, and algae remover often to ensure that adequate fresh cleaner is used and that surface remains wet.

4. Rinse with cold water applied by medium-pressure spray to remove mold, mildew, and algae remover and soil.
5. Repeat cleaning procedure above where required to produce cleaning effect established by mockup.

3.6 FIELD QUALITY CONTROL

A. Field Service: Architect/Engineer to be on-site not less than once to review cleaning process with Owner during preconstruction, and to observe progress and quality of the work.

3.7 FINAL CLEANING

A. Clean adjacent non-masonry surfaces of spillage and debris. Use detergent and soft brushes or cloths.

B. Remove debris from gutters and downspouts. Rinse off roof and flush gutters and downspouts.

C. Remove masking materials, leaving no residues that could trap dirt.

END OF SECTION 040110

SECTION 040120.63 - BRICK MASONRY REPAIR

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. Repairing brick masonry.
2. Removing abandoned anchors.
3. Painting steel uncovered during the work.

B. Related Requirements:

1.3 UNIT PRICES

A. Work of this Section is affected by unit prices specified in Section 012200 "Unit Prices."

1. Unit prices apply to authorized work covered by quantity allowances.
2. Unit prices apply to additions to and deletions from Work as authorized by Change Orders.

1.4 DEFINITIONS

A. Low-Pressure Spray: 100 to 400 psi (690 to 2750 kPa); 4 to 6 gpm (0.25 to 0.4 L/s).

B. Rebuilding (Setting) Mortar: Mortar used to set and anchor masonry in a structure, distinct from pointing mortar installed after masonry is set in place.

C. Saturation Coefficient: Ratio of the weight of water absorbed during immersion in cold water to weight absorbed during immersion in boiling water; used as an indication of resistance of bricks to freezing and thawing.

1.5 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1. Review methods and procedures related to brick masonry repair including, but not limited to, the following:

a. Verify brick masonry repair specialist's personnel, equipment, and facilities needed to make progress and avoid delays.
b. Materials, material application, sequencing, tolerances, and required clearances.
c. Quality-control program.
d. Coordination with building occupants.

## 1.6 SEQUENCING AND SCHEDULING

A. Order sand and gray portland cement for colored mortar immediately after approval of mockups. Take delivery of and store at Project site enough quantity to complete Project.

B. Work Sequence: Perform brick masonry repair work in the following sequence, which includes work specified in this and other Sections:

1. Remove plant growth.
2. Inspect masonry for open mortar joints and point them before cleaning to prevent the intrusion of water and other cleaning materials into the wall.
3. Remove paint.
4. Clean masonry.
5. Rake out mortar from joints surrounding masonry to be replaced and from joints adjacent to masonry repairs along joints.
6. Repair masonry, including replacing existing masonry with new masonry materials.
7. Rake out mortar from joints to be repointed.
8. Point mortar and sealant joints.
9. After repairs and repointing have been completed and cured, perform a final cleaning to remove residues from this work.
10. Where water repellents are to be used on or near masonry work, delay application of these chemicals until after pointing and cleaning.

C. As scaffolding is removed, patch anchor holes used to attach scaffolding. Patch holes in bricks according to "Brick Masonry Patching" Article. Patch holes in mortar joints according to Section 040120.64 "Brick Masonry Repointing."

## 1.7 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Include recommendations for product application and use.
3. Include test data substantiating that products comply with requirements.

B. Shop Drawings:

1. Include plans, elevations, sections, and locations of replacement bricks on the structure, showing relation of existing and new or relocated units.
2. Show provisions for expansion joints or other sealant joints.
3. Show provisions for flashing, lighting fixtures, conduits, and weep holes as required.

4. Show locations of scaffolding and points of scaffolding in contact with masonry. Include details of each point of contact or anchorage.

C. Samples for Initial Selection: For the following:

1. Colored Mortar: Submit sets of mortar that will be left exposed in the form of sample mortar strips, 6 inches (150 mm) long by 1/4 inch (6 mm)wide, set in aluminum or plastic channels.

   a. Have each set contain a close color range of at least three Samples of different mixes of colored sands and cements that produce a mortar matching existing, cleaned mortar when cured and dry.
   b. Submit with precise measurements on ingredients, proportions, gradations, and source of colored sands from which each Sample was made.

2. Sand Types Used for Mortar: Minimum 8 oz. (240 mL) of each in plastic screw-top jars.
3. Patching Compound: Submit sets of patching compound Samples in the form of plugs (patches in drilled holes) in sample units of masonry representative of the range of masonry colors on the building.

   a. Have each set contain a close color range of at least three Samples of different mixes of patching compound that matches the variations in existing masonry when cured and dry.

4. Include similar Samples of accessories involving color selection.

D. Samples for Verification: For the following:

1. Each type of brick unit to be used for replacing existing units. Include sets of Samples to show the full range of shape, color, and texture to be expected. For each brick type, provide straps or panels containing at least four bricks. Include multiple straps for brick with a wide range.
2. Each type of patching compound in the form of briquettes, at least 3 inches (75 mm) long by 1-1/2 inches (38 mm) wide. Document each Sample with manufacturer and stock number or other information necessary to order additional material.
3. Accessories: Each type of accessory and miscellaneous support.

## 1.8 INFORMATIONAL SUBMITTALS

A. Qualification Data: For brick masonry repair specialist including field supervisors and workers and testing service.

B. Preconstruction Test Reports: For existing bricks and mortar and replacement bricks.

C. Quality-control program.

## 1.9 QUALITY ASSURANCE

A. Quality-Control Program: Prepare a written quality-control program for this Project to systematically demonstrate the ability of personnel to properly follow methods and use

materials and tools without damaging masonry. Include provisions for supervising performance and preventing damage.

B. Mockups: Prepare mockups of brick masonry repair to demonstrate aesthetic effects and to set quality standards for materials and execution and for fabrication and installation.

1. Masonry Repair: Construct sample areas in locations in existing walls where directed by Architect unless otherwise indicated. Demonstrate quality of materials, workmanship, and blending with existing work. Include the following as a minimum:

a. Matching of existing brick: Four brick units minimum.

## 1.10 PRECONSTRUCTION TESTING

A. Preconstruction Testing Service: Architect will engage a qualified testing agency to perform preconstruction testing on brick masonry as follows:

1. Provide test specimens as indicated and representative of proposed materials and existing construction.
2. Replacement Brick: Test each proposed type of replacement brick according to sampling and testing methods in ASTM C67 for compressive strength, 24-hour cold-water absorption, five-hour boil absorption, saturation coefficient, and initial rate of absorption (suction).
3. Existing Brick: Test each type of existing brick indicated for replacement according to testing methods in ASTM C67 for compressive strength, 24-hour cold-water absorption, five-hour boil absorption, saturation coefficient, and initial rate of absorption (suction). Carefully remove five existing units from locations designated by Architect. Take testing samples from these units.
4. Existing Mortar: Test according to ASTM C1324, modified as agreed by testing service and Architect for Project requirements, to determine proportional composition of original ingredients, sizes and colors of aggregates, and approximate strength.
5. Temporary Patch: As directed by Architect, provide temporary materials followed by permanent repairs at locations from which existing samples were taken.

## 1.11 DELIVERY, STORAGE, AND HANDLING

A. Deliver bricks to Project site strapped together in suitable packs or pallets or in heavy-duty cartons and protected against impact and chipping.

B. Deliver packaged materials to Project site in manufacturer's original and unopened containers, labeled with manufacturer's name and type of products.

C. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.

D. Store hydrated lime in manufacturer's original and unopened containers. Discard lime if containers have been damaged or have been opened for more than two days.

E. Store sand where grading and other required characteristics can be maintained and contamination avoided.

F. Handle bricks to prevent overstressing, chipping, defacement, and other damage.

1.12 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit brick masonry repair work to be performed according to product manufacturers' written instructions and specified requirements.

B. Temperature Limits: Repair brick masonry only when air temperature is between 40 and 90 deg F (4 and 32 deg C) and is predicted to remain so for at least seven days after completion of the Work unless otherwise indicated.

C. Hot-Weather Requirements: Protect masonry repairs when temperature and humidity conditions produce excessive evaporation of water from mortar and repair materials. Provide artificial shade and wind breaks, and use cooled materials as required to minimize evaporation. Do not apply mortar to substrates with temperatures of 90 deg F (32 deg C) and above unless otherwise indicated.

D. For manufactured repair materials, perform work within the environmental limits set by each manufacturer.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Source Limitations: Obtain each type of material for repairing brick masonry (brick, cement, sand, etc.) from single source with resources to provide materials of consistent quality in appearance and physical properties.

2.2 MASONRY MATERIALS

A. Face Brick: As required to complete brick masonry repair work.

1. Brick Matching Existing: Units with colors, color variation within units, surface texture, size, and shape that match existing brickwork and with physical properties within 10 percent of those determined from preconstruction testing of selected existing units.

a. For existing brickwork that exhibits a range of colors or color variation within units, provide brick that proportionally matches that range and variation rather than brick that matches an individual color within that range.

2. Brick Matching Architect's Sample: Units with colors, color variation within units, surface texture, and physical properties that match Architect's sample. Match existing units in size and shape.

a. For Architect's sample that exhibits a range of colors or color variation within units, provide brick that proportionally matches that range rather than brick that matches an individual color within that range.

3. Special Shapes:

a. Provide molded, 100 percent solid shapes for applications where core holes or "frogs" could be exposed to view or weather when in final position and where shapes produced by sawing would result in sawed surfaces being exposed to view.
b. Provide specially ground units, shaped to match patterns, for arches and where indicated.
c. Mechanical chopping or breaking brick, or bonding pieces of brick together by adhesive, are unacceptable procedures for fabricating special shapes.

4. Tolerances as Fabricated: According to tolerance requirements in ASTM C216, Type FBX.

5. Grade SW where in contact with earth.
6. Grade SW, MW, or NW for concealed backup.

## 2.3 MORTAR MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or Type II, except Type III may be used for cold-weather construction; white or gray, or both where required for color matching of mortar.

1. Provide cement containing not more than 0.60 percent total alkali when tested according to ASTM C114.

B. Hydrated Lime: ASTM C207, Type S.

C. Masonry Cement: ASTM C91/C91M.

D. Mortar Cement: ASTM C1329/C1329M.

E. Mortar Sand: ASTM C144.

1. Exposed Mortar: Match size, texture, and gradation of existing mortar sand as closely as possible. Blend several sands if necessary to achieve suitable match.

F. Mortar Pigments: ASTM C979/C979M, compounded for use in mortar mixes, and having a record of satisfactory performance in masonry mortars.

G. Water: Potable.

## 2.4 MANUFACTURED REPAIR MATERIALS

A. Brick Patching Compound: Factory-mixed cementitious product that is custom manufactured for patching brick masonry.

1. Use formulation that is vapor and water permeable (equal to or more than the brick), exhibits low shrinkage, has lower modulus of elasticity than bricks being repaired, and develops high bond strength to all types of masonry.
2. Use formulation having working qualities and retardation control to permit forming and sculpturing where necessary.
3. Formulate patching compound in colors and textures to match each brick being patched. Provide sufficient number of colors to enable matching of the color, texture, and variation of each unit.

## 2.5 ACCESSORY MATERIALS

A. Setting Buttons and Shims: Resilient plastic, nonstaining to masonry, sized to suit joint thicknesses and bed depths of bricks, less the required depth of pointing materials unless removed before pointing.

B. Masking Tape: Nonstaining, nonabsorbent material; compatible with mortar, joint primers, sealants, and surfaces adjacent to joints; and that easily comes off entirely, including adhesive.

C. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer according to MPI #23 (surface-tolerant, anticorrosive metal primer) or SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating.

1. Surface Preparation: Use coating requiring no better than SSPC-SP 3, "Power Tool Cleaning" or SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning" surface preparation according to manufacturer's literature or certified statement.
2. VOC Limit: Use coating with a VOC content of 400 g/L (3.3 lb/gal.) or less.

D. Other Products: Select materials and methods of use based on the following, subject to approval of a mockup:

1. Previous effectiveness in performing the work involved.
2. Minimal possibility of damaging exposed surfaces.
3. Consistency of each application.
4. Uniformity of the resulting overall appearance.
5. Do not use products or tools that could leave residue on surfaces.

## 2.6 MORTAR MIXES

A. Measurement and Mixing: Measure cementitious materials and sand in a dry condition by volume or equivalent weight. Do not measure by shovel; use known measure. Mix materials in a clean, mechanical batch mixer.

B. Colored Mortar: Produce mortar of color required by using specified ingredients. Do not alter specified proportions without Architect's approval.

C. Do not use admixtures in mortar unless otherwise indicated.

D. Mixes: Mix mortar materials in the following proportions:

1. Rebuilding (Setting) Mortar by Volume: ASTM C270, Proportion Specification, 1 part portland cement, 1 part lime, and 6 parts sand.
2. Rebuilding (Setting) Mortar by Type: ASTM C270, Proportion Specification, Type N unless otherwise indicated; with cementitious material limited to portland cement and lime or mortar cement.

## PART 3 - EXECUTION

### 3.1 REPAIR SPECIALIST

### 3.2 PROTECTION

A. Prevent mortar from staining face of surrounding masonry and other surfaces.

1. Cover sills, ledges, and other projecting items to protect them from mortar droppings.
2. Keep wall area wet below rebuilding and repair work to discourage mortar from adhering.
3. Immediately remove mortar splatters in contact with exposed masonry and other surfaces.

B. Remove gutters and downspouts and associated hardware adjacent to masonry and store during masonry repair. Reinstall when repairs are complete.

1. Provide temporary rain drainage during work to direct water away from building.

### 3.3 MASONRY REPAIR, GENERAL

A. Appearance Standard: Repaired surfaces are to have a uniform appearance as viewed from 20 feet (6 m) 50 feet (15 m) away by Architect.

### 3.4 ABANDONED ANCHOR REMOVAL

A. Remove abandoned anchors, brackets, wood nailers, and other extraneous items no longer in use unless indicated to remain

1. Remove items carefully to avoid spalling or cracking masonry.
2. Notify Architect before proceeding if an item cannot be removed without damaging surrounding masonry. Do the following where directed:

   a. Cut or grind off item approximately 3/4 inch (20 mm) beneath surface and core drill a recess of same depth in surrounding masonry as close around item as practical.
   b. Immediately paint exposed end of item with two coats of antirust coating, following coating manufacturer's written instructions and without exceeding manufacturer's recommended dry film thickness per coat. Keep paint off sides of recess.

3. Patch hole where each item was removed unless directed to remove and replace bricks.

## 3.5 BRICK REMOVAL AND REPLACEMENT

A. At locations indicated, remove bricks that are damaged, spalled, or deteriorated or are to be reused. Carefully remove entire units from joint to joint, without damaging surrounding masonry, in a manner that permits replacement with full-size units.

   1. When removing single bricks, remove material from center of brick and work toward outside edges.

B. Support and protect remaining masonry that surrounds removal area.

C. Maintain flashing, reinforcement, lintels, and adjoining construction in an undamaged condition. Coordinate with new flashing, reinforcement, and lintels, which are specified in other Sections.

D. Notify Architect of unforeseen detrimental conditions including voids, cracks, bulges, and loose units in existing masonry backup, rotted wood, rusted metal, and other deteriorated items.

E. Remove in an undamaged condition as many whole bricks as possible.

   1. Remove mortar, loose particles, and soil from brick by cleaning with hand chisels, brushes, and water.
   2. Remove sealants by cutting close to brick with utility knife and cleaning with solvents.
   3. Store brick for reuse. Store off ground, on skids, and protected from weather.
   4. Deliver cleaned brick not required for reuse to Owner unless otherwise indicated.

F. Clean masonry surrounding removal areas by removing mortar, dust, and loose particles in preparation for brick replacement.

G. Replace removed damaged brick with other removed brick in good condition, where possible, or with new brick matching existing brick. Do not use broken units unless they can be cut to usable size.

H. Install replacement brick into bonding and coursing pattern of existing brick. If cutting is required, use a motor-driven saw designed to cut masonry with clean, sharp, unchipped edges.

   1. Maintain joint width for replacement units to match existing joints.
   2. Use setting buttons or shims to set units accurately spaced with uniform joints.

I. Lay replacement brick with rebuilding (setting) mortar and with completely filled bed, head, and collar joints. Butter ends with enough mortar to fill head joints and shove into place. Wet both replacement and surrounding bricks that have ASTM C67 initial rates of absorption (suction) of more than 30 g/30 sq. in. per min. (30 g/194 sq. cm per min.) Use wetting methods that ensure that units are nearly saturated but surface is dry when laid.

   1. Tool exposed mortar joints in repaired areas to match joints of surrounding existing brickwork.
   2. Rake out mortar used for laying brick before mortar sets according to Section 040120.64 "Brick Masonry Repointing." Point at same time as repointing of surrounding area.
   3. When mortar is hard enough to support units, remove shims and other devices interfering with pointing of joints.

J. Curing: Cure mortar by maintaining in thoroughly damp condition for at least 72 consecutive hours, including weekends and holidays.

1. Hairline cracking within the mortar or mortar separation at edge of a joint is unacceptable. Completely remove such mortar and repoint.

## 3.6 PAINTING STEEL UNCOVERED DURING THE WORK

A. Notify Architect if steel is exposed during masonry removal. Where Architect determines that steel is structural, or for other reasons cannot be totally removed, prepare and paint it as follows:

1. Surface Preparation: Remove paint, rust, and other contaminants according to SSPC-SP 3, "Power Tool Cleaning" or SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning", as applicable to comply with paint manufacturer's recommended preparation.
2. Antirust Coating: Immediately paint exposed steel with two coats of antirust coating, following coating manufacturer's written instructions and without exceeding manufacturer's recommended rate of application (dry film thickness per coat).

## 3.7 BRICK MASONRY PATCHING

A. Patch the following bricks unless another type of repair or replacement is indicated:

1. Bricks indicated to be patched.
2. Bricks with holes.
3. Bricks with chipped edges or corners. Patch chipped edges or corners measuring more than 3/4 inch (19 mm) in least dimension.
4. Bricks with small areas of deep deterioration. Patch deep deteriorations measuring more than 3/4 inch (19 mm) in least dimension and more than 1/4 inch (6 mm) deep.

B. Remove and replace existing patches unless otherwise indicated or approved by Architect.

C. Patching Bricks:

1. Remove loose material from masonry surface. Carefully remove additional material so patch does not have feathered edges but has square or slightly undercut edges on area to be patched and is at least 1/4 inch (6 mm) thick, but not less than recommended in writing by patching compound manufacturer.
2. Mask adjacent mortar joint or rake out for repointing if patch extends to edge of brick.
3. Mix patching compound in individual batches to match each unit being patched. Combine one or more colors of patching compound, as needed, to produce exact match.
4. Rinse surface to be patched and leave damp, but without standing water.
5. Brush-coat surfaces with slurry coat of patching compound according to manufacturer's written instructions.
6. Place patching compound in layers as recommended in writing by patching compound manufacturer, but not less than 1/4 inch (6 mm) or more than 2 inches (50 mm) thick. Roughen surface of each layer to provide a key for next layer.
7. Trowel, scrape, or carve surface of patch to match texture and surrounding surface plane or contour of brick. Shape and finish surface before or after curing, as determined by testing, to best match existing brick.

8. Keep each layer damp for 72 hours or until patching compound has set.
9. Remove and replace patches with hairline cracks or that show separation from brick at edges, and those that do not match adjoining brick in color or texture.

## 3.8 FINAL CLEANING

A. After mortar has fully hardened, thoroughly clean exposed masonry surfaces of excess mortar and foreign matter; use wood scrapers, stiff-nylon or -fiber brushes, and clean water applied by low-pressure spray.

1. Do not use metal scrapers or brushes.
2. Do not use acidic or alkaline cleaners.

B. Clean adjacent non-masonry surfaces. Use detergent and soft brushes or cloths.

C. Clean mortar and debris from roof; remove debris from gutters and downspouts. Rinse off roof and flush gutters and downspouts.

D. Remove masking materials, leaving no residues that could trap dirt.

## 3.9 FIELD QUALITY CONTROL

A. Testing Agency: Architect/Engineer to perform inspections. Architect's Project Representatives: Architect will assign Project representatives to help carry out Architect's responsibilities at the site, including observing progress and quality of portion of the Work completed. Allow Architect's Project representatives use of lift devices and scaffolding, as needed, to observe progress and quality of portion of the Work completed.

B. Notify Architect's Project representatives in advance of times when lift devices and scaffolding will be relocated. Do not relocate lift devices and scaffolding until Architect's Project representatives have had reasonable opportunity to make inspections and observations of work areas at lift device or scaffold location.

## 3.10 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property.

B. Masonry Waste: Remove masonry waste and legally dispose of off Owner's property.

END OF SECTION 040120.63

SECTION 042000 - UNIT MASONRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete masonry units.
2. Lintels.
3. Brick.
4. Mortar and grout materials.
5. Reinforcement.
6. Ties and anchors.
7. Embedded flashing.
8. Accessories.
9. Mortar and grout mixes.

B. Products Installed but not Furnished under This Section:
1. Steel lintels in unit masonry.
2. Steel shelf angles for supporting unit masonry.
3. Cavity wall insulation adhered to masonry backup.

C. Related Requirements:
1. Section 031000 "Concrete Forms and Accessories" for installing dovetail or channel slots for masonry-veneer anchors.
2. Section 072100 "Thermal Insulation" for cavity wall insulation.
3. Section 076200 "Sheet Metal Flashing and Trim" for exposed sheet metal flashing and for furnishing manufactured reglets installed in masonry joints.

1.2 DEFINITIONS

A. CMU(s): Concrete masonry unit(s).

B. Reinforced Masonry: Masonry containing reinforcing steel in grouted cells.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Qualification Data: For Installer, including list of ABAA-certified installers and supervisors employed by Installer, who work on Project

B. Product Data: For each type of product.

C. Shop Drawings: For the following:

1. Masonry Units: Indicate sizes, profiles, coursing, and locations of special shapes.
2. Reinforcing Steel: Indicate bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315R.
3. Fabricated Flashing: Detail corner units, end-dam units, and other special applications.

D. Samples for Verification: For each type and color of the following:
1. Clay face Hollow brick
2. Cavity drainage material.

E. Delegated Design Submittals: For masonry anchors and ties, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

## 1.5 INFORMATIONAL SUBMITTALS

A. List of Materials Used in Constructing Mockups: List generic product names together with manufacturers, manufacturers' product names, model numbers, lot numbers, batch numbers, source of supply, and other information as required to identify materials used. Include mix proportions for mortar and grout and source of aggregates.

1. Submittal is for information only. Receipt of list does not constitute approval of deviations from the Contract Documents unless such deviations are specifically brought to the attention of Architect and approved in writing.

B. Material Certificates: For each type of the following:

1. Masonry units.

a. Include data on material properties material test reports substantiating compliance with requirements.
b. For brick, include size-variation data verifying that actual range of sizes falls within specified tolerances.
c. For exposed brick, include test report for efflorescence in accordance with ASTM C67/C67M.
d. For surface-coated brick, include test report for durability of surface appearance after 50 cycles of freezing and thawing in accordance with ASTM C67/C67M or a list of addresses of buildings in Project's area where proposed brick has been used successfully and with a history of durability.
e. For masonry units, include data and calculations establishing average net-area compressive strength of units.
2. Cementitious materials. Include name of manufacturer, brand name, and type.
3. Mortar admixtures.
4. Preblended, dry mortar mixes. Include description of type and proportions of ingredients.
5. Grout mixes. Include description of type and proportions of ingredients.
6. Reinforcing bars.
7. Joint reinforcement.
8. Anchors, ties, and metal accessories.

C. Qualification Statements: For testing agency.

D. Delegated design engineer qualifications.

E. Mix Designs: For each type of mortar and grout. Include description of type and proportions of ingredients.

1. Include test reports for mortar mixes required to comply with property specification. Test in accordance with ASTM C109/C109M for compressive strength, ASTM C1506 for water retention, and ASTM C91/C91M for air content.
2. Include test reports, in accordance with ASTM C1019, for grout mixes required to comply with compressive strength requirement.

F. Statement of Compressive Strength of Masonry: For each combination of masonry unit type and mortar type, provide statement of average net-area compressive strength of masonry units, mortar type, and resulting net-area compressive strength of masonry determined in accordance with TMS 602.

G. Cold-Weather and Hot-Weather Procedures: Detailed description of methods, materials, and equipment to be used to comply with requirements.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Store masonry units on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied. If units become wet, do not install until they are dry.

B. Deliver preblended, dry mortar mix in moisture-resistant containers. Store preblended, dry mortar mix in delivery containers on elevated platforms in a dry location or in covered weatherproof dispensing silos.

C. Store masonry accessories, including metal items, to prevent corrosion and accumulation of dirt and oil.

## 1.7 FIELD CONDITIONS

A. Protection of Masonry: During construction, cover tops of walls, projections, and sills with waterproof sheeting at end of each day's work. Cover partially completed masonry when construction is not in progress.

1. Extend cover a minimum of 24 inches (610 mm) down both sides of walls, and hold cover securely in place.
2. Where one wythe of multi-wythe masonry walls is completed in advance of other wythes, secure cover a minimum of 24 inches (610 mm) down face next to unconstructed wythe, and hold cover in place.

B. Do not apply uniform floor or roof loads for at least 12 hours and concentrated loads for at least three days after building masonry walls or columns.

C. Stain Prevention: Prevent grout, mortar, and soil from staining the face of masonry to be left exposed or painted. Immediately remove grout, mortar, and soil that come in contact with such masonry.

1. Protect base of walls from rain-splashed mud and from mortar splatter by spreading coverings on ground and over wall surface.
2. Protect sills, ledges, and projections from mortar droppings.
3. Protect surfaces of window and door frames, as well as similar products with painted and integral finishes, from mortar droppings.
4. Turn scaffold boards near the wall on edge at the end of each day to prevent rain from splashing mortar and dirt onto completed masonry.

D. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in TMS 602.

PART 2 - PRODUCTS

2.1 SOURCE LIMITATIONS

A. Obtain cementitious mortar components and mortar aggregate from single producer or manufacturer.

B. For exposed masonry units and cementitious mortar components, obtain each color and grade from single source with resources to provide materials of consistent quality in appearance and physical properties.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design .

B. Seismic Performance: Masonry to withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.

C. Provide structural unit masonry that develops indicated net-area compressive strengths at 28 days.

1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) in accordance with TMS 602.

2.3 UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 602, except as modified by requirements in the Contract Documents.

B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such

defects are exposed in the completed Work and will be within 20 ft. (6 m) vertically and horizontally of a walking surface.

C. Fire-Resistance Ratings: Comply with requirements for fire-resistance-rated assembly designs indicated.

1. Where fire-resistance-rated construction is indicated, units are listed by UL or a qualified testing agency acceptable to authorities having jurisdiction.

## 2.4 CONCRETE MASONRY UNITS

A. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.

1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
2. Provide square-edged units for outside corners unless otherwise indicated.

B. CMUs: ASTM C90, normal weight.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 3050 psi (21.0 MPa).
2. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less than nominal dimensions.
3. Exposed Faces: Provide color and texture matching the range represented by Architect's sample.

C. Concrete Building Brick: ASTM C55, normal weight.

1. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 3050 psi (21.0 MPa).
2. Size (Actual Dimensions): 3-5/8 inches (92 mm) wide by 2-1/4 inches (57 mm) high by 7-5/8 inches (194 mm) long.
3. Unit Compressive Strength: Provide units with minimum average net-area compressive strength of 3050 psi (21.0 MPa).
4. Size (Width): Manufactured to dimensions specified in "CMUs" Paragraph above.
5. Pattern and Texture: Standard pattern, ground-face finish.
6. Colors: As indicated by manufacturer's designations.

## 2.5 LINTELS

A. Solid Concrete Masonry Lintels: ASTM C1623, matching CMUs in color, texture, and density classification; and with reinforcing bars indicated. Provide lintels with net-area compressive strength of not less than that of CMUs.

B. Concrete Lintels: Precast or formed-in-place concrete lintels complying with requirements in Section 032000 "Concrete Reinforcing," and with reinforcing bars indicated.

C. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout. Cure precast lintels before handling and installing. Temporarily support built-in-place lintels until cured.

D. Offset Angle Supports: Steel plate brackets anchored to structure, allowing continuous insulation behind shelf angle supporting veneer. Component and anchor size and spacing engineered by manufacturer.
   1. Carbon Steel, Galvanized after Fabrication: ASTM A1008/A1008M, with ASTM A153/A153M, Class B coating.

## 2.6 BRICK

A. General: Provide shapes indicated and as follows, with exposed surfaces matching finish and color of exposed faces of adjacent units:

   1. For ends of sills and caps and for similar applications that would otherwise expose unfinished brick surfaces, provide units without cores or frogs and with exposed surfaces finished.
   2. Provide special shapes for applications where stretcher units cannot accommodate special conditions, including those at corners, movement joints, bond beams, sashes, and lintels where shapes produced by sawing would result in sawed surfaces being exposed to view.

B. Clay Face Brick: Facing brick complying with ASTM C216 or hollow brick complying with ASTM C652, Class H40V (void areas between 25 and 40 percent of gross cross-sectional area), Grade MW or Grade SW

   **1. Match existing brick.**
      a. Manufacturers:
         1) Brick Repair Work – (254) 855-2819
         2) Acme Brick – (409) 899-4171
         3) South Texas Brick – (281) 759-3100
   2. Initial Rate of Absorption: Less than 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested in accordance with ASTM C67/C67M.
   3. Efflorescence: Provide brick that has been tested in accordance with ASTM C67/C67M and is rated "not effloresced."
   4. Size (Actual Dimensions): Field verify dimensions and brick type.
   5. Application: Use where brick is exposed unless otherwise indicated.
   6. Where shown to "match existing," provide face brick matching color range, texture, and size of existing adjacent brickwork.

## 2.7 MORTAR AND GROUT MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

   1. Alkali content will not be more than 0.1 percent when tested in accordance with ASTM C114.

B. Hydrated Lime: ASTM C207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.

D. Masonry Cement: ASTM C91/C91M.

E. Mortar Cement: ASTM C1329/C1329M.

F. Preblended Dry Mortar Mix: Packaged blend made from portland cement and hydrated lime, sand, water repellents, and admixtures and complying with ASTM C1714/C1714M.

1. Preblended Dry Portland Cement Mortar Mix:

2. Preblended Dry Masonry Cement Mortar Mix

G. Aggregate for Mortar: ASTM C144.

1. For mortar that is exposed to view, use washed aggregate consisting of natural sand or crushed stone.
2. For joints less than 1/4 inch (6.4 mm) thick, use aggregate graded with 100 percent passing the No. 16 (1.18-mm) sieve.
3. White-Mortar Aggregates: Natural white sand or crushed white stone.
4. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

H. Aggregate for Grout: ASTM C404.

I. Cold-Weather Admixture: Non-chloride, noncorrosive, accelerating admixture complying with ASTM C494/C494M, Type C , and recommended by manufacturer for use in masonry mortar of composition indicated.

J. Water: Potable.

## 2.8 REINFORCEMENT

A. Uncoated-Steel Reinforcing Bars: ASTM A615/A615M or ASTM A996/A996M, Grade 60 (Grade 420).

B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

C. Masonry-Joint Reinforcement, General: ASTM A951/A951M.

1. Interior Walls: Hot-dip galvanized carbon steel.
2. Exterior Walls: Hot-dip galvanized carbon steel.
3. Wire Size for Side Rods: 0.187-inch (4.76-mm)] diameter.
4. Wire Size for Cross Rods: 0.187-inch (4.76-mm)] diameter.
5. Wire Size for Veneer Ties: 0.187-inch (4.76-mm)] diameter.

6. Spacing of Cross Rods, Tabs, and Cross Ties: Not more than 16 inches (406 mm) o.c.
7. Provide in lengths of not less than 10 ft. (3 m), with prefabricated corner and tee units.

D. Masonry-Joint Reinforcement for Single-Wythe Masonry: Ladder or truss type with single pair of side rods.
1. Ladder type with one side rod at each face shell of hollow masonry units more than 4 inches (102 mm) wide, plus two side rods at each wythe of masonry 4 inches (102 mm) wide or less.
2. Tab type, either ladder or truss design, with one side rod at each face shell of backing wythe and with rectangular tabs sized to extend at least halfway through facing wythe, but with at least 5/8-inch (16-mm) cover on outside face.
3. Adjustable (two-piece) type, either ladder or truss design, with one side rod at each face shell of backing wythe and with separate adjustable ties with pintle-and-eye connections having a maximum horizontal play of 1/16 inch (1.6 mm) and maximum vertical adjustment of 1-1/4 inches (32 mm). Size ties to extend at least halfway through facing wythe but with at least 5/8-inch (16-mm) cover on outside face Ties have hooks or clips to engage a continuous horizontal wire in the facing wythe.

E. Masonry-Joint Reinforcement for Veneers Anchored with Seismic Masonry-Veneer Anchors: Single 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized carbon steel continuous wire.

## 2.9 TIES AND ANCHORS

A. General: Ties and anchors extend at least 1-1/2 inches (38 mm) into veneer but with at least a 5/8-inch (16-mm) cover on outside face.

B. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:
1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A1064/A1064M, with ASTM A153/A153M, Class B-2 coating.
2. Stainless Steel Bars: ASTM A276 or ASTM A666, Type 304.

C. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6.4-mm-) diameter ,hot-dip galvanized steel wire.
2. Tie Section: Triangular-shaped wire tie made from 0.187-inch- (4.76-mm-)hot-dip galvanized steel wire. Mill-galvanized wire may be used at interior walls unless otherwise indicated.]

D. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Connector Section: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from 0.105-inch- (2.66-mm-) thick steel sheet, galvanized after fabrication

a. 0.064-inch- (1.63-mm-)thick, galvanized-steel sheet may be used at interior walls unless otherwise indicated.

2. Tie Section: Triangular-shaped wire tie made from 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized steel wire. Mill-galvanized wire may be used at interior walls unless otherwise indicated.

E. Partition Top Anchors: 0.105-inch- (2.66-mm-) thick metal plate with a 3/8-inch- (10-mm-) diameter metal rod 6 inches (152 mm) long welded to plate and with closed-end plastic tube fitted over rod that allows rod to move in and out of tube. Fabricate from steel, hot-dip galvanized after fabrication.

F. Rigid Anchors: Fabricate from steel bars 1-1/2 inches (38 mm) wide by 1/4 inch (6.4 mm) thick by 24 inches (610 mm) long, with ends turned up 2 inches (51 mm) or with cross pins unless otherwise indicated.

1. Corrosion Protection: Hot-dip galvanized to comply with ASTM A153/A153M .

G. Adjustable Masonry-Veneer Anchors:

1. General: Provide anchors that allow vertical adjustment but resist a 100 lbf (445 N) load in both tension and compression perpendicular to plane of wall without deforming or developing play in excess of 1/16 inch (1.6 mm).
2. Fabricate sheet metal anchor sections and other sheet metal parts from0.1084-inch- (2.75-mm-) thick steel sheet, galvanized after fabrication.
3. Fabricate wire ties from 0.187-inch- (4.76-mm-) diameter, hot-dip galvanized-steel wire unless otherwise indicated.
4. Contractor's Option: Unless otherwise indicated, provide any of the adjustable masonry-veneer anchors specified.
5. Masonry-Veneer Anchors; Single-Barrel Screw with Double-Pintle Tapcon: Self-drilling, single-barrel screw with thermally resistant wingnut head thermally resistant clip designed to receive double-pintle wire tie. Screw has a smooth barrel the same thickness as insulation with factory-installed gasketed washer to seal at face of insulation and sheathing and a coating to reduce thermal conductivity. Provide with seismic tie, clip, and continuous wire in veneer.

## 2.10 EMBEDDED FLASHING

A. Metal Flashing: Provide metal flashing complying with SMACNA's "Architectural Sheet Metal Manual" and as follows:

1. Stainless Steel: ASTM A240/A240M or ASTM A666, Type 304, 0.016 inch (0.40 mm) thick.
2. Fabricate continuous flashings in sections 96 inches (2438 mm) long minimum, but not exceeding 12 ft. (3.7 m). Provide splice plates at joints of formed, smooth metal flashing.
3. Fabricate through-wall flashing with snap lock receiver on exterior face where indicated to receive counterflashing.
4. Fabricate through-wall flashing with drip edge unless otherwise indicated. Fabricate by extending flashing 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.

5. Fabricate through-wall flashing with sealant stop unless otherwise indicated. Fabricate by bending metal back on itself 3/4 inch (19 mm) at exterior face of wall and down into joint 1/4 inch (6.4 mm) to form a stop for retaining sealant backer rod.
6. Fabricate metal drip edges from stainless steel. Extend at least 3 inches (76 mm) into wall and 1/2 inch (13 mm) out from wall, with outer edge bent down 30 degrees and hemmed.
7. Fabricate metal sealant stops from stainless steel. Extend at least 3 inches (76 mm) into wall and out to exterior face of wall. At exterior face of wall, bend metal back on itself for 3/4 inch (19 mm) and down into joint 1/4 inch (6.4 mm) to form a stop for retaining sealant backer rod.
8. Fabricate metal expansion-joint strips from stainless steel to shapes indicated.
9. Solder metal items at corners.
10. Elastomeric Thermoplastic Flashing: Composite flashing product consisting of a polyester-reinforced ethylene interpolymer alloy.
    a. Monolithic Sheet: Elastomeric thermoplastic flashing, 40 mil (1.0 mm) thick.
    b. Self-Adhesive Sheet: Elastomeric thermoplastic flashing, 25 mil (0.64 mm) thick, with a 15-mil- (0.38-mm-) thick coating of adhesive.

        1) Color: Black.

    c. Accessories: Provide preformed corners, end dams, other special shapes, and seaming materials produced by flashing manufacturer.

B. Solder and Sealants for Sheet Metal Flashings: As specified in Section 076200 "Sheet Metal Flashing and Trim."

1. Solder for Stainless Steel: ASTM B32, Grade Sn60, with acid flux of type recommended by stainless steel sheet manufacturer.
2. Elastomeric Sealant: ASTM C920, chemically curing urethane sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and remain watertight.

C. Adhesives, Primers, and Seam Tapes for Flashings: Flashing manufacturer's standard products or products recommended by flashing manufacturer for bonding flashing sheets to each other and to substrates.

D. Termination Bars for Flexible Flashing: Stainless steel bars 1/8 inch by 1-1/8 inch (3.2 mm by 29 mm).

E. Termination Bars for Flexible Flashing, Flanged: Stainless steel sheet 0.019 inch by 1-1/2 inches (0.48 mm by 38 mm) with a 3/8-inch (10-mm) flange at top and bottom.

## 2.11 ACCESSORIES

A. Compressible Filler: Pre-molded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neopreneor PVC.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D2000, Designation M2AA-805 or] PVC, complying with ASTM D2287,

Type PVC-65406 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D226/D226M, Type I (No. 15 asphalt felt).

D. Weep/Cavity Vents: Use one of the following unless otherwise indicated:

1. Wicking Material: Absorbent rope, made from cotton, 1/4 to 3/8 inch (6.4 to 10 mm) in diameter, in length required to produce 2-inch (51-mm) exposure on exterior and 18 inches (457 mm) in cavity. Use only for weeps.
2. Round Plastic Weep/Vent Tubing: Medium-density polyethylene, 3/8-inch (10-mm) OD by 4 inches (102 mm) long.

## 2.12 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

1. Do not use calcium chloride in mortar or grout.
2. Use portland cement-lime or mortar cement mortar unless otherwise indicated.
3. For exterior masonry, use portland cement-lime masonry cement or mortar cement mortar.
4. For reinforced masonry, use portland cement-lime masonry cement or mortar cement mortar.
5. Add cold-weather admixture (if used) at same rate for all mortar that will be exposed to view, regardless of weather conditions, to ensure that mortar color is consistent.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.

1. For masonry below grade or in contact with earth, use Type M.
2. For reinforced masonry, use Type M.
3. For exterior, above-grade, load-bearing, nonload-bearing walls, and parapet walls; for interior load-bearing walls; for interior nonload-bearing partitions; and for other applications where another type is not indicated, use Type N.
4. For interior nonload-bearing partitions, Type O may be used instead of Type N.

D. Grout for Unit Masonry: Comply with ASTM C476.

1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 602 for dimensions of grout spaces and pour height.
2. Proportion grout in accordance with ASTM C476, Table 1 or paragraph 4.2.1.2 for specified 28-day compressive strength indicated, but not less than 2000 psi (14 MPa).

3. Provide grout with a slump of 8 to 11 inches (203 to 279 mm) as measured in accordance with ASTM C143/C143M.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
2. Verify that foundations are within tolerances specified.
3. Verify that reinforcing dowels are properly placed.
4. Verify that substrates are free of substances that impair mortar bond.

B. Before installation, examine rough-in and built-in construction for piping systems to verify actual locations of piping connections.

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

### 3.2 INSTALLATION, GENERAL

A. Thickness: Build cavity and composite walls and other masonry construction to full thickness shown. Build single-wythe walls to actual widths of masonry units, using units of widths indicated.

B. Build chases and recesses to accommodate items specified in this and other Sections.

C. Leave openings for equipment to be installed before completing masonry. After installing equipment, complete masonry to match construction immediately adjacent to opening.

D. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

E. Select and arrange units for exposed unit masonry to produce a uniform blend of colors and textures. Mix units from several pallets or cubes as they are placed.

F. Matching Existing Masonry: Match coursing, bonding, color, and texture of existing masonry.

G. Wetting of Brick: Wet brick before laying if initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested in accordance with ASTM C67/C67M. Allow units to absorb water so they are damp but not wet at time of laying.

## 3.3 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (13 mm) or minus 1/4 inch (6.4 mm).
2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (13 mm).
3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6.4 mm) in a story height or 1/2 inch (13 mm) total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 ft. (6.4 mm in 3 m), or 1/2-inch (13-mm) maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 ft. (3.2 mm in 3 m), 1/4 inch in 20 ft. (6.4 mm in 6 m), or 1/2-inch (13-mm) maximum.
3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 ft. (6.4 mm in 3 m), 3/8 inch in 20 ft. (10 mm in 6 m), or 1/2-inch (13-mm) maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 ft. (3.2 mm in 3 m), 1/4 inch in 20 ft. (6.4 mm in 6 m), or 1/2-inch (13-mm) maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 ft. (6.4 mm in 3 m), 3/8 inch in 20 ft. (10 mm in 6 m), or 1/2-inch (13-mm) maximum.
6. For vertical alignment of exposed head joints, do not vary from plumb by more than 1/4 inch in 10 ft. (6.4 mm in 3 m), or 1/2-inch (13-mm) maximum.
7. For faces of adjacent exposed masonry units, do not vary from flush alignment by more than 1/16 inch (1.6 mm) except due to warpage of masonry units within tolerances specified for warpage of units.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3.2 mm), with a maximum thickness limited to 1/2 inch (13 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3.2 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (10 mm) or minus 1/4 inch (6.4 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3.2 mm). Do not vary from adjacent bed-joint and head-joint thicknesses by more than 1/8 inch (3.2 mm).
5. For exposed bed joints and head joints of stacked bond, do not vary from a straight line by more than 1/16 inch (1.6 mm) from one masonry unit to the next.

## 3.4 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets.

Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond do not use units with less-than-nominal 4-inch (102-mm) horizontal face dimensions at corners or jambs.

C. Stopping and Resuming Work: Stop work by stepping back units in each course from those in course below; do not tooth. When resuming work, clean masonry surfaces that are to receive mortar, remove loose masonry units and mortar, and wet brick if required before laying fresh masonry.

D. Built-in Work: As construction progresses, build in items specified in this and other Sections. Fill in solidly with masonry around built-in items.

E. Fill space between steel frames and masonry solidly with mortar unless otherwise indicated.

F. Where built-in items are to be embedded in cores of hollow masonry units, place a layer of metal lath, wire mesh, or plastic mesh in the joint below, and rod mortar or grout into core.

G. Fill cores in hollow CMUs with grout 24 inches (610 mm) under bearing plates, beams, lintels, posts, and similar items unless otherwise indicated.

H. Build nonload-bearing interior partitions full height of story to underside of solid floor or roof structure above unless otherwise indicated.

1. Install compressible filler in joint between top of partition and underside of structure above.
2. Fasten partition top anchors to structure above and build into top of partition. Grout cells of CMUs solidly around plastic tubes of anchors, and push tubes down into grout to provide 1/2-inch (13-mm) clearance between end of anchor rod and end of tube. Space anchors 48 inches (1219 mm) o.c. unless otherwise indicated.
3. Wedge nonload-bearing partitions against structure above with small pieces of tile, slate, or metal. Fill joint with mortar after dead-load deflection of structure above approaches final position.
4. At fire-rated partitions, treat joint between top of partition and underside of structure above to comply with Section 078443 "Joint Firestopping."

## 3.5 MORTAR BEDDING AND JOINTING

A. Lay CMUs and hollow brick as follows:

1. Bed face shells in mortar and make head joints of depth equal to bed joints.
2. Bed webs in mortar in all courses of piers, columns, and pilasters.
3. Bed webs in mortar in grouted masonry, including starting course on footings.
4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.
5. Fully bed units and fill cells with mortar at anchors and ties as needed to fully embed anchors and ties in mortar.

B. Lay solid masonry units and hollow brick with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

E. Cut joints flush where indicated to receive waterproofing unless otherwise indicated.

## 3.6 COMPOSITE MASONRY

A. Bond wythes of composite masonry together using one of the following methods:

1. Individual Metal Ties: Provide ties as indicated installed in horizontal joints, but not less than one metal tie for 2.67 sq. ft. (0.25 sq. m) of wall area spaced not to exceed 24 inches (610 mm) 16 inches (406 mm) o.c. horizontally and 16 inches (406 mm) o.c. vertically. Stagger ties in alternate courses. Provide additional ties within 12 inches (305 mm) of openings and space not more than 36 inches (914 mm) apart around perimeter of openings. At intersecting and abutting walls, provide ties at no more than 24 inches (610 mm) o.c. vertically.

    a. Where bed joints of wythes do not align, use adjustable-type (two-piece-type) ties.

2. Masonry-Joint Reinforcement: Installed in horizontal mortar joints.

    a. Where bed joints of both wythes align, use ladder-type reinforcement extending across both wythes.
    b. Where bed joints of wythes do not align, use adjustable-type (two-piece-type) reinforcement with continuous horizontal wire in facing wythe attached to ties.

3. Header Bonding: Provide masonry unit headers extending not less than 3 inches (76 mm) into each wythe. Space headers not more than 12 inches (300 mm) clear horizontally and 16 inches (400 mm) clear vertically.

B. Bond wythes of composite masonry together using bonding system indicated on Drawings.

C. Collar Joints: Solidly fill collar joints by parging face of first wythe that is laid and shoving units of other wythe into place.

D. Collar Joints in Clay Tile Masonry: After each course is laid, fill the vertical, longitudinal joint between wythes solidly with mortar at exterior walls, except cavity walls

E. Corners: Provide interlocking masonry unit bond in each wythe and course at corners unless otherwise indicated.

1. Provide continuity with masonry-joint reinforcement at corners by using prefabricated L-shaped units as well as masonry bonding.

F. Intersecting and Abutting Walls: Unless vertical expansion or control joints are indicated at juncture, bond walls together as follows:

1. Provide individual metal ties not more than 16 inches (406 mm) o.c.
2. Provide continuity with masonry-joint reinforcement by using prefabricated T-shaped units.
3. Provide rigid metal anchors not more than 24 inches (610 mm) o.c. If used with hollow masonry units, embed ends in mortar-filled cores.

## 3.7 ANCHORED MASONRY VENEERS

A. Anchor masonry veneers to wall framing and concrete and masonry backup with seismic masonry-veneer anchors to comply with the following requirements:

1. Fasten screw-attached anchors through sheathing to wall framing and to concrete and masonry backup with metal fasteners of type indicated. Use two fasteners unless anchor design only uses one fastener.
2. Embed connector sections and continuous wire in masonry joints.
3. Locate anchor sections to allow maximum vertical differential movement of ties up and down.
4. Space anchors as indicated, but not more than 16 inches (406 mm) o.c. vertically and 25 inches (635 mm) o.c. horizontally, with not less than one anchor for each 2.67 sq. ft. (0.25 sq. m) of wall area. Install additional anchors within 12 inches (305 mm) of openings and at intervals, not exceeding 36 inches (914 mm), around perimeter.

B. Provide not less than 2 inches (51 mm) of airspace between back of masonry veneer and face of insulation.

1. Keep airspace clean of mortar droppings and other materials during construction. Bevel beds away from airspace, to minimize mortar protrusions into airspace. Do not attempt to trowel or remove mortar fins protruding into airspace.

## 3.8 MASONRY-JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (152 mm).

1. Space reinforcement not more than 16 inches (406 mm) o.c.
2. Space reinforcement not more than 8 inches (203 mm) o.c. in foundation walls and parapet walls.
3. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings in addition to continuous reinforcement.

B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

C. Provide continuity at corners by using prefabricated L-shaped units.

D. Cut and bend reinforcing units as directed by manufacturer for continuity at corners, returns, offsets, column fireproofing, pipe enclosures, and other special conditions.

## 3.9 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:

1. Provide an open space not less than 1 inch (25 mm) wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (914 mm) o.c. horizontally.

## 3.10 CONTROL JOINTS

A. General: Install control- and expansion-joint materials in unit masonry as masonry progresses. Do not allow materials to span control and expansion joints without provision to allow for in-plane wall or partition movement.

B. Form control joints in concrete masonry using one of the following methods:

1. Fit bond-breaker strips into hollow contour in ends of CMUs on one side of control joint. Fill resultant core with grout, and rake out joints in exposed faces for application of sealant.
2. Install preformed control-joint gaskets designed to fit standard sash block.
3. Install interlocking units designed for control joints. Install bond-breaker strips at joint. Keep head joints free and clear of mortar, or rake out joint for application of sealant.
4. Install temporary foam-plastic filler in head joints, and remove filler when unit masonry is complete for application of sealant.

C. Provide horizontal, pressure-relieving joints by either leaving an airspace or inserting a compressible filler of width required for installing sealant and backer rod specified in Section 079200 "Joint Sealants," but not less than 3/8 inch (10 mm).

1. Locate horizontal, pressure-relieving joints beneath shelf angles supporting masonry.

## 3.11 LINTELS

A. Provide masonry or offset angle support lintels where indicated and where openings of more than 12 inches (305 mm) for brick-size units and 24 inches (610 mm) for block-size units are indicated without structural steel or other supporting lintels.

B. Provide minimum bearing of 8 inches (203 mm) at each jamb unless otherwise indicated.

## 3.12 FLASHING, WEEP HOLES, AND CAVITY VENTS

A. General: Install embedded flashing and weep holes in masonry at shelf angles, lintels, ledges, other obstructions to downward flow of water in wall, and where indicated. Install cavity vents at shelf angles, ledges, and other obstructions to upward flow of air in cavities, and where indicated.

B. Install flashing as follows unless otherwise indicated:

1. Prepare masonry surfaces so they are smooth and free from projections that could puncture flashing. Where flashing is within mortar joint, place through-wall flashing on sloping bed of mortar and cover with mortar. Before covering with mortar, seal penetrations in flashing with adhesive, sealant, or tape as recommended by flashing manufacturer.
2. At masonry-veneer walls, extend flashing through veneer, across airspace behind veneer, and up face of sheathing at least 8 inches (203 mm); with upper edge tucked under water-resistive barrier, lapping at least 4 inches (102 mm). Fasten upper edge of flexible flashing to sheathing through termination bar.
3. At lintels and shelf angles, extend flashing 6 inches (152 mm) minimum, to edge of next full unit at each end. At heads and sills, extend flashing 6 inches (152 mm) minimum, to edge of next full unit and turn ends up not less than 2 inches (51 mm) to form end dams.
4. Interlock end joints of sawtooth sheet metal flashing by overlapping ribs not less than 1-1/2 inches (38 mm) or as recommended by flashing manufacturer, and seal lap with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
5. Install metal drip edges and sealant stops with sawtooth sheet metal flashing by interlocking hemmed edges to form hooked seam. Seal seam with elastomeric sealant complying with requirements in Section 079200 "Joint Sealants" for application indicated.
6. Install metal flashing termination beneath flexible flashing at exterior face of wall. Stop flexible flashing 1/2 inch (13 mm) back from outside face of wall, and adhere flexible flashing to top of metal flashing termination.

C. Install single-wythe CMU flashing system in bed joints of CMU walls where indicated to comply with manufacturer's written instructions. Install CMU cell pans with upturned edges located below face shells and webs of CMUs above and with weep spouts aligned with face of wall. Install CMU web covers so that they cover upturned edges of CMU cell pans at CMU webs and extend from face shell to face shell.

D. Install reglets and nailers for flashing and other related construction where they are indicated to be built into masonry.

E. Install weep holes in exterior wythes and veneers in head joints of first course of masonry immediately above embedded flashing.

1. Use specified weep/cavity vent products or open-head joints to form weep holes.
2. Use wicking material to form weep holes above flashing under brick sills. Turn wicking down at lip of sill to be as inconspicuous as possible.
3. Space weep holes 24 inches (610 mm) o.c. unless otherwise indicated.
4. Space weep holes formed from plastic tubing or wicking material 16 inches (406 mm) o.c.

5. Cover cavity side of weep holes with plastic insect screening at cavities insulated with loose-fill insulation.
6. Trim wicking material flush with outside face of wall after mortar has set.

F. Place pea gravel in cavities as soon as practical to a height equal to height of first course above top of flashing, but not less than 2 inches (51 mm), to maintain drainage.

1. Fill cavities full height by placing pea gravel in cavities as masonry is laid, so that at any point, masonry does not extend more than 24 inches (610 mm) above top of pea gravel.

G. Place cavity drainage material in cavities to comply with configuration requirements for cavity drainage material in "Accessories" Article.

H. Install cavity vents in head joints in exterior wythes at spacing indicated. Use specified weep/cavity vent products or open-head joints to form cavity vents.

1. Close cavities off vertically and horizontally with blocking in manner indicated. Install through-wall flashing and weep holes above horizontal blocking.

## 3.13 REINFORCED UNIT MASONRY

A. Placing Reinforcement: Comply with requirements in TMS 602.

B. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.

1. Comply with requirements in TMS 602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.
2. Limit height of vertical grout pours to not more than 60 inches (1524 mm).

## 3.14 FIELD QUALITY CONTROL

A. Testing Agency: Architect/Engineer to perform inspections. Allow A/E access to scaffolding and work areas as needed to perform tests and inspections. Retesting of materials that fail to comply with specified requirements will be at Contractor's expense.

B. Clay Masonry Unit: Each type of unit provided, shall be in accordance with ASTM C67/C67M for compressive strength.

C. Concrete Masonry Unit: Each type of unit provided, shall be in accordance with ASTM C140/C140M for compressive strength.

D. Mortar Aggregate Ratio (Proportion Specification): Each mix provided, shall be in accordance with ASTM C780.

E. Mortar (Property Specification): Each mix provided, shall be in accordance with ASTM C780 for mortar air content and compressive strength.

F. Grout (Compressive Strength): Each mix provided, shall be in accordance with ASTM C1019.

## 3.15 PARGING

A. Parge exterior faces of below-grade masonry walls, where indicated, in two uniform coats to a total thickness of 3/4 inch (19 mm). Dampen wall before applying first coat, and scarify first coat to ensure full bond to subsequent coat.

B. Use a steel-trowel finish to produce a smooth, flat, dense surface with a maximum surface variation of 1/8 inch per foot (3.2 mm per 305 mm). Form a wash at top of parging and a cove at bottom.

C. Damp-cure parging for at least 24 hours and protect parging until cured.

## 3.16 REPAIRING, POINTING, AND CLEANING

A. Remove and replace masonry units that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Install new units to match adjoining units; install in fresh mortar, pointed to eliminate evidence of replacement.

B. Pointing: During the tooling of joints, enlarge voids and holes, except weep holes, and completely fill with mortar. Point up joints, including corners, openings, and adjacent construction, to provide a neat, uniform appearance. Prepare joints for sealant application, where indicated.

C. In-Progress Cleaning: Clean unit masonry as work progresses by dry brushing to remove mortar fins and smears before tooling joints.

D. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.
3. Protect adjacent stone and non-masonry surfaces from contact with cleaner by covering them with liquid strippable masking agent or polyethylene film and waterproof masking tape.
4. Wet wall surfaces with water before applying cleaners; remove cleaners promptly by rinsing surfaces thoroughly with clear water.
5. Clean brick by bucket-and-brush hand-cleaning method described in BIA Technical Notes 20.
6. Clean concrete masonry by applicable cleaning methods indicated in NCMA TEK 8-4A.
7. Clean masonry with a proprietary acidic masonry cleaner applied according to manufacturer's written instructions.

## 3.17 MASONRY WASTE DISPOSAL

A. Salvageable Materials: Unless otherwise indicated, excess masonry materials are Contractor's property. At completion of unit masonry work, remove from Project site.

B. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.

1. Crush masonry waste to less than 4 inches (102 mm) in each dimension.
2. Mix masonry waste with at least two parts of specified fill material for each part of masonry waste. Fill material is specified in Section 312000 "Earth Moving."
3. Do not dispose of masonry waste as fill within 18 inches (457 mm) of finished grade.

C. Masonry Waste Recycling: Return broken CMUs not used as fill to manufacturer for recycling.

D. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION 042000

SECTION 042200 - CONCRETE UNIT MASONRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Concrete masonry units.
2. Mortar and grout materials.
3. Reinforcement.
4. Masonry-joint reinforcement.
5. Embedded flashing materials.
6. Miscellaneous masonry accessories.
7. Masonry-cell insulation.

B. Products Installed, but Not Furnished, under This Section:

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site

1.3 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: For the following: Reinforcing Steel: Detail bending, lap lengths, and placement of unit masonry reinforcing bars. Comply with ACI 315.

C. Samples for Verification: For each type and color of the following:

1. Exposed CMUs.
2. Colored-aggregate mortar.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Material certificates.

C. Mix designs.

## 1.5 QUALITY ASSURANCE

A. Project team craftworkers of the Masonry Contractor assigned to Project will be required to have the International Masonry Institute - Flashing Training or equal and to provide evidence of certificate or a letter of the firm's commitment to enroll key project personnel in the training program prior to the start of Project.

B. Project team craftworkers of the Masonry Contractor assigned to Project will be required to have the International Masonry Institute - Grouting and Reinforcing Training or equal and to provide evidence of certificate or a letter of the firm's commitment to enroll key project personnel in the training program prior to the start of Project.

C. Testing Agency Qualifications: Qualified in accordance with ASTM C1093 for testing indicated.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Provide structural unit masonry that develops indicated net-area compressive strengths at 28 days.

1. Determine net-area compressive strength of masonry from average net-area compressive strengths of masonry units and mortar types (unit-strength method) in accordance with Tables 1 and 2 in TMS 402/602.

B. Regulatory Requirements: Comply with the provisions of the following codes, specifications, and standards, except as otherwise shown or specified:

1. TMS 402/602.

## 2.2 CONCRETE UNIT MASONRY, GENERAL

A. Masonry Standard: Comply with TMS 402/602 except as modified by requirements in the Contract Documents.

B. Defective Units: Referenced masonry unit standards may allow a certain percentage of units to contain chips, cracks, or other defects exceeding limits stated. Do not use units where such defects are exposed in the completed Work.

C. Shapes: Provide shapes indicated and as follows, with exposed surfaces matching exposed faces of adjacent units unless otherwise indicated.

1. Provide special shapes for lintels, corners, jambs, sashes, movement joints, headers, bonding, and other special conditions.
2. Provide bullnose units for outside corners unless otherwise indicated.

D. Concrete Building Brick: ASTM C55.

E. Building Lintels:

1. Masonry Lintels: Prefabricated or built-in-place masonry lintels made from bond beam CMUs matching adjacent CMUs in color, texture, and density classification, with reinforcing bars placed as indicated and filled with coarse grout.

a. Knockout blocks will not be acceptable.

## 2.3 CONCRETE MASONRY UNITS

A. Standard CMUs: Load-bearing ASTM C90 and non-load-bearing ASTM C129.
1. Density Classification: Normal weight
2. Size (Width): Manufactured to dimensions 3/8 inch (10 mm) less-than-nominal dimensions.

## 2.4 MORTAR AND GROUT MATERIALS

A. Portland Cement: ASTM C150/C150M, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

1. Alkali content is not more than 0.1 percent when tested in accordance with ASTM C114.

B. Hydrated Lime: ASTM C207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement and hydrated lime containing no other ingredients.

D. Masonry Cement: ASTM C91/C91M.

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

a. Cemex S.A.B. de C.V.
b. Heidelberg Materials.
c. Holcim (US) Inc.
d. Lafarge North America Inc.

E. Aggregate for Mortar: ASTM C144.

1. White-Mortar Aggregates: Natural white sand or crushed white stone.
2. Colored-Mortar Aggregates: Natural sand or crushed stone of color necessary to produce required mortar color.

F. Aggregate for Grout: ASTM C404.

## 2.5 REINFORCEMENT

A. Uncoated-Steel Reinforcing Bars: ASTM A615/A615M or ASTM A996/A996M, Grade 60 (Grade 420).

B. Reinforcing Bar Positioners: Wire units designed to fit into mortar bed joints spanning masonry unit cells and to hold reinforcing bars in center of cells. Units are formed from 0.148-inch (3.77-mm) steel wire, hot-dip galvanized after fabrication. Provide units designed for number of bars indicated.

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

   a. Heckmann Building Products, Inc.
   b. Hohmann & Barnard, Inc.
   c. Wire-Bond.

C. Masonry-Joint Reinforcement, General: Ladder type complying with ASTM A951/A951M.

1. Interior Walls: Hot-dip galvanized carbon steel.
2. Exterior Walls: Hot-dip galvanized carbon steel.
3. Wire Size for Side Rods: 0.187-inch (4.76-mm) diameter.
4. Wire Size for Cross Rods: 0.187-inch (4.76-mm) diameter.
5. Spacing of Cross Rods: Not more than 16 inches (406 mm) o.c.

## 2.6 TIES AND ANCHORS

A. Materials: Provide ties and anchors specified in this article that are made from materials that comply with the following unless otherwise indicated:

1. Hot-Dip Galvanized, Carbon-Steel Wire: ASTM A82/A82M, with ASTM A153/A153M, Class B-2 coating.
2. Steel Plates, Shapes, and Bars: ASTM A36/A36M.

B. Adjustable Anchors for Connecting to Structural Steel Framing: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

1. Anchor Section for Welding to Steel Frame: Crimped 1/4-inch- (6-mm-) diameter, hot-dip galvanized steel.

C. Adjustable Anchors for Connecting to Concrete: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

## 2.7 MISCELLANEOUS MASONRY ACCESSORIES

A. Compressible Filler: Premolded filler strips complying with ASTM D1056, Grade 2A1; compressible up to 35 percent; of width and thickness indicated; formulated from neoprene or PVC.

B. Preformed Control-Joint Gaskets: Made from styrene-butadiene-rubber compound, complying with ASTM D2000, Designation M2AA-805 or PVC, complying with ASTM D2287, Type PVC-65406 and designed to fit standard sash block and to maintain lateral stability in masonry wall; size and configuration as indicated.

C. Bond-Breaker Strips: Asphalt-saturated felt complying with ASTM D226/D226M, Type I (No. 15 asphalt felt).

D. Masonry Cleaners:

1. Proprietary Acidic Masonry Cleaner: Manufacturer's standard-strength, general-purpose cleaner designed for removing mortar/grout stains, efflorescence, and other new construction stains from masonry surfaces of type indicated below without discoloring or damaging masonry surfaces; expressly approved for intended use by manufacturer of masonry units being cleaned.

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

1) Diedrich Technologies, Inc.; a Hohmann & Barnard company.
2) EaCo Chem, Inc.
3) PROSOCO, Inc.

## 2.8 MASONRY-CELL INSULATION

A. Masonry-Cell Fill: Lightweight-aggregate fill, ASTM C331/C331M.

## 2.9 MORTAR AND GROUT MIXES

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures unless otherwise indicated.

1. Do not use calcium chloride in mortar or grout.
2. Use portland cement-lime mortar unless otherwise indicated.

B. Preblended, Dry Mortar Mix: Furnish dry mortar ingredients in form of a preblended mix. Measure quantities by weight to ensure accurate proportions, and thoroughly blend ingredients before delivering to Project site.

C. Mortar for Unit Masonry: Comply with ASTM C270, Proportion Specification. Provide the following types of mortar for applications stated unless another type is indicated or needed to provide required compressive strength of masonry.
1. For reinforced masonry, use Type N.
2. For mortar parge coats, use Type N.
3. For interior non-load-bearing partitions, Type O may be used instead of Type N.

D. Grout for Unit Masonry: Comply with ASTM C476.

1. Use grout of type indicated or, if not otherwise indicated, of type (fine or coarse) that will comply with TMS 402/602 for dimensions of grout spaces and pour height.
2. Proportion grout in accordance with ASTM C476, Table 1 or paragraph 4.2.2 for specified 28-day compressive strength indicated, but not less than 2000 psi (14 MPa).
3. Provide grout with a slump of 8 to 11 inches (200 to 280 mm) as measured in accordance with ASTM C143/C143M.

## PART 3 - EXECUTION

### 3.1 INSTALLATION, GENERAL

A. Use full-size units without cutting if possible. If cutting is required to provide a continuous pattern or to fit adjoining construction, cut units with motor-driven saws; provide clean, sharp, unchipped edges. Allow units to dry before laying unless wetting of units is specified. Install cut units with cut surfaces and, where possible, cut edges concealed.

B. Exposed Masonry: Mix units to product uniform blend of colors and textures.

C. Where existing masonry occurs, match coursing, bonding, color, and texture of existing masonry.

D. Temperature Control: Perform temperature-sensitive construction procedures while masonry Work is progressing. Temperature ranges vary at time of installation, except for grout. For grout, temperature ranges apply to anticipated minimum night temperatures. In heating mortar and grout materials, maintain mixing temperature selected within 10 deg F (6 deg C).

E. Masonry Protection: Protect completed masonry and masonry not being worked by the required day and night anticipated minimum air temperatures.

### 3.2 TOLERANCES

A. Dimensions and Locations of Elements:

1. For dimensions in cross section or elevation, do not vary by more than plus 1/2 inch (13 mm) or minus 1/4 inch (6 mm).
2. For location of elements in plan, do not vary from that indicated by more than plus or minus 1/2 inch (13 mm).
3. For location of elements in elevation, do not vary from that indicated by more than plus or minus 1/4 inch (6 mm) in a story height or 1/2 inch (13 mm) total.

B. Lines and Levels:

1. For bed joints and top surfaces of bearing walls, do not vary from level by more than 1/4 inch in 10 ft. (6 mm in 3 m), or 1/2 inch (13 mm) maximum.
2. For conspicuous horizontal lines, such as lintels, sills, parapets, and reveals, do not vary from level by more than 1/8 inch in 10 ft. (3 mm in 3 m), 1/4 inch in 20 ft. (6 mm in 6 m), or 1/2 inch (13 mm) maximum.

3. For vertical lines and surfaces, do not vary from plumb by more than 1/4 inch in 10 ft. (6 mm in 3 m), 3/8 inch in 20 ft. (9 mm in 6 m), or 1/2 inch (13 mm) maximum.
4. For conspicuous vertical lines, such as external corners, door jambs, reveals, and expansion and control joints, do not vary from plumb by more than 1/8 inch in 10 ft. (3 mm in 3 m), 1/4 inch in 20 ft. (6 mm in 6 m), or 1/2 inch (13 mm) maximum.
5. For lines and surfaces, do not vary from straight by more than 1/4 inch in 10 ft. (6 mm in 3 m), 3/8 inch in 20 ft. (9 mm in 6 m), or 1/2 inch (13 mm) maximum.

C. Joints:

1. For bed joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm), with a maximum thickness limited to 1/2 inch (13 mm).
2. For exposed bed joints, do not vary from bed-joint thickness of adjacent courses by more than 1/8 inch (3 mm).
3. For head and collar joints, do not vary from thickness indicated by more than plus 3/8 inch (9 mm) or minus 1/4 inch (6 mm).
4. For exposed head joints, do not vary from thickness indicated by more than plus or minus 1/8 inch (3 mm).

## 3.3 LAYING MASONRY WALLS

A. Lay out walls in advance for accurate spacing of surface bond patterns with uniform joint thicknesses and for accurate location of openings, movement-type joints, returns, and offsets. Avoid using less-than-half-size units, particularly at corners, jambs, and, where possible, at other locations.

B. Bond Pattern for Exposed Masonry: Unless otherwise indicated, lay exposed masonry in running bond; do not use units with less-than-nominal 4-inch (100-mm) horizontal face dimensions at corners or jambs.

## 3.4 MORTAR BEDDING AND JOINTING

A. Lay hollow CMUs as follows:

1. Bed face shells in mortar and make head joints of depth equal to bed joints.
2. Bed webs in mortar in all courses of piers, columns, and pilasters.
3. Bed webs in mortar in grouted masonry, including starting course on footings.
4. Fully bed entire units, including areas under cells, at starting course on footings where cells are not grouted.

B. Lay solid CMUs with completely filled bed and head joints; butter ends with sufficient mortar to fill head joints and shove into place. Do not deeply furrow bed joints or slush head joints.

C. Tool exposed joints slightly concave when thumbprint hard, using a jointer larger than joint thickness unless otherwise indicated.

D. Cut joints flush for masonry walls to receive plaster or other direct-applied finishes (other than paint) unless otherwise indicated.

## 3.5 MASONRY-JOINT REINFORCEMENT

A. General: Install entire length of longitudinal side rods in mortar with a minimum cover of 5/8 inch (16 mm) on exterior side of walls, 1/2 inch (13 mm) elsewhere. Lap reinforcement a minimum of 6 inches (150 mm).

1. Space reinforcement not more than 16 inches (406 mm) o.c.
2. Provide reinforcement not more than 8 inches (203 mm) above and below wall openings and extending 12 inches (305 mm) beyond openings.

B. Interrupt joint reinforcement at control and expansion joints unless otherwise indicated.

C. Provide continuity at wall intersections by using prefabricated T-shaped units.

D. Provide continuity at corners by using prefabricated L-shaped units.

## 3.6 ANCHORING MASONRY TO STRUCTURAL STEEL AND CONCRETE

A. Anchor masonry to structural steel and concrete, where masonry abuts or faces structural steel or concrete, to comply with the following:

1. Provide an open space not less than 1/2 inch (13 mm) wide between masonry and structural steel or concrete unless otherwise indicated. Keep open space free of mortar and other rigid materials.
2. Anchor masonry with anchors embedded in masonry joints and attached to structure.
3. Space anchors as indicated, but not more than 24 inches (610 mm) o.c. vertically and 36 inches (915 mm) o.c. horizontally.

## 3.7 CONTROL JOINTS

A. General: Install control joint materials in CMUs as masonry progresses. Do not allow materials to span control joints without provision to allow for in-plane wall or partition movement.

B. Locate control joints. Comply with NCMA TEK 10-02D.

## 3.8 LINTELS

A. Install lintels over openings as indicated.

B. Provide concrete or formed-in-place masonry lintels where shown and where openings of more than 24 inches (610 mm) for block-size units are shown without structural steel or other supporting lintels. Provide minimum bearing of 8 inches (200 mm) at each jamb unless otherwise indicated.

C. Lintels at Fire-Rated Openings: Provide fire-rated masonry required or steel lintels with applied fireproofing in thickness required to maintain fire rating of wall or partition rating.

## 3.9 REINFORCED UNIT MASONRY

A. Temporary Formwork and Shores: Construct formwork and shores as needed to support reinforced masonry elements during construction.

1. Construct formwork to provide shape, line, and dimensions of completed masonry as indicated. Make forms sufficiently tight to prevent leakage of mortar and grout. Brace, tie, and support forms to maintain position and shape during construction and curing of reinforced masonry.
2. Do not remove forms and shores until reinforced masonry members have hardened sufficiently to carry their own weight and other loads that may be placed on them during construction.

B. Placing Reinforcement: Comply with requirements in TMS 402/602.

C. Grouting: Do not place grout until entire height of masonry to be grouted has attained enough strength to resist grout pressure.

1. Comply with requirements in TMS 402/602 for cleanouts and for grout placement, including minimum grout space and maximum pour height.

## 3.10 FIELD QUALITY CONTROL

A. Inspections: Architect/Engineer will perform inspections and prepare field reports. Allow A/E access to work areas as needed to perform inspections. Testing of materials that fail to comply with specified requirements is done at Contractor's expense.

## 3.11 PARGING

A. Use a steel-trowel finish to produce a smooth, flat, dense surface with a maximum surface variation of 1/8 inch per foot (3 mm per 300 mm). Form a wash at top of parging and a cove at bottom.

B. Damp-cure parging for at least 24 hours and protect parging until cured.

## 3.12 REPAIRING, POINTING, AND CLEANING

A. In-Progress Cleaning: Clean unit masonry as Work progresses by dry brushing to remove mortar fins and smears before tooling joints.

B. Final Cleaning: After mortar is thoroughly set and cured, clean exposed masonry as follows:

1. Remove large mortar particles by hand with wooden paddles and nonmetallic scrape hoes or chisels.
2. Test cleaning methods on sample wall panel; leave one-half of panel uncleaned for comparison purposes. Obtain Architect's approval of sample cleaning before proceeding with cleaning of masonry.

3.13 MASONRY WASTE DISPOSAL

A. Waste Disposal as Fill Material: Dispose of clean masonry waste, including excess or soil-contaminated sand, waste mortar, and broken masonry units, by crushing and mixing with fill material as fill is placed.

B. Masonry Waste Recycling: Return broken CMUs not used as fill to manufacturer for recycling.

C. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, as described above or recycled, and other masonry waste, and legally dispose of off Owner's property.

END OF SECTION 042200

SECTION 061000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Framing with dimension lumber.
2. Framing with engineered wood products.
3. Rooftop equipment bases and support curbs.
4. Wood blocking, cants, and nailers.
5. Wood furring
6. Wood sleepers.
7. Plywood backing panels.

1.2 ACTION SUBMITTALS

A. Product Data:

1. For each type of process and factory-fabricated product.
2. For preservative-treated wood products.

1.3 INFORMATIONAL SUBMITTALS

A. Material Certificates:

1. For dimension lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by the ALSC Board of Review.
2. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

B. Evaluation Reports: For the following, from ICC-ES:

1. Wood-preservative-treated wood.
2. Fire-retardant-treated wood.
3. Engineered wood products.
4. Shear panels.
5. Power-driven fasteners.
6. Metal framing anchors.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Lumber: Comply with DOC PS 20 and applicable rules of grading agencies indicated. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by the ALSC Board of Review. Grade lumber by an agency certified by the ALSC Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Dress lumber: S4S.

B. Maximum Moisture Content:

1. Boards: 15 percent.
2. Dimension Lumber: 15 percent for 2-inch nominal (38-mm actual) thickness or less; unless otherwise indicated.

2.2 PRESERVATIVE TREATMENT

A. Preservative Treatment by Pressure Process: AWPA U1; Use Category UC2 for interior construction not in contact with ground, Use Category UC3b for exterior construction not in contact with ground, and Use Category UC4a for items in contact with ground.

1. Preservative Chemicals: Acceptable to authorities having jurisdiction and containing no arsenic or chromium. Do not use inorganic boron (SBX) for sill plates.

B. Kiln-dry lumber after treatment to a maximum moisture content of 19 percent. Do not use material that is warped or that does not comply with requirements for untreated material.

C. Mark lumber with treatment quality mark of an inspection agency approved by the ALSC Board of Review.

D. Application: Treat all rough carpentry unless otherwise indicated.

2.3 FIRE-RETARDANT-TREATMENT

A. General: Where fire-retardant-treated materials are indicated, materials are to comply with requirements in this article, that are acceptable to authorities having jurisdiction, and with fire-test-response characteristics specified as determined by testing identical products per test method indicated by a qualified testing agency.

B. Fire-Retardant-Treated Lumber and Plywood by Pressure Process: Products with a flame-spread index of 25 or less when tested according to ASTM E84, and with no evidence of significant progressive combustion when the test is extended an additional 20 minutes, and with the flame front not extending more than 10.5 feet (3.2 m) beyond the centerline of the burners at any time during the test.

1. Exterior Type: Treated materials are to comply with requirements specified above for fire-retardant-treated lumber and plywood by pressure process after being subjected to accelerated weathering according to ASTM D2898. Use for exterior locations and where indicated.
2. Interior Type A: Treated materials are to have a moisture content of 28 percent or less when tested according to ASTM D3201/D3201M at 92 percent relative humidity. Use where exterior type is not indicated.

C. Kiln-dry lumber after treatment to maximum moisture content of 19 percent.

D. Identify fire-retardant-treated wood with appropriate classification marking of qualified testing agency.

E. Application: Treat all rough carpentry unless otherwise indicated.

## 2.4 MISCELLANEOUS LUMBER

A. Provide miscellaneous lumber indicated and lumber for support or attachment of other construction, including the following:

1. Blocking.
2. Nailers.
3. Rooftop equipment bases and support curbs.
4. Cants.
5. Furring.
6. Grounds.

B. Concealed Boards: 15 percent maximum moisture content and any of the following species and grades:

1. Mixed southern pine or southern pine; No. 2 grade; SPIB.
2. Eastern softwoods; No. [2] [3] Common grade; NeLMA.

## 2.5 PLYWOOD BACKING PANELS

A. Equipment Backing Panels: Plywood, DOC PS 1, fire-retardant treated, in thickness indicated or, if not indicated, not less than /4-inch (19-mm) nominal thickness.

## 2.6 FASTENERS

A. General: Fasteners are to be of size and type indicated and comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.

1. Where rough carpentry is exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide fasteners with hot-dip zinc coating complying with ASTM A153/A153M.

B. Power-Driven Fasteners: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC70.

## 2.7 METAL FRAMING ANCHORS

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

1. MiTek Industries, Inc.
2. Simpson Strong-Tie Co., Inc.
3. Tamlyn.

B. Allowable design loads, as published by manufacturer, are to meet or exceed those of basis-of-design products. Manufacturer's published values are to be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency. Framing anchors are to be punched for fasteners adequate to withstand same loads as framing anchors.

C. Galvanized-Steel Sheet: Hot-dip, zinc-coated steel sheet complying with ASTM A653/A653M, G60 (Z180) coating designation.

1. Use for interior locations unless otherwise indicated.

## 2.8 MISCELLANEOUS MATERIALS

A. Sill-Sealer Gaskets:

1. Glass-fiber-resilient insulation, fabricated in strip form, for use as a sill sealer; 1-inch (25-mm) nominal thickness, compressible to 1/32 inch (0.8 mm); selected from manufacturer's standard widths to suit width of sill members indicated.
2. Closed-cell neoprene foam, 1/4 inch (6.4 mm) thick, selected from manufacturer's standard widths to suit width of sill members indicated.
3. Self-adhering sheet consisting of 64mils (1.6 mm) of rubberized asphalt laminated on one side to a 4-mil- (0.10-mm-) thick, polyethylene-film reinforcement, and with release liner on adhesive side; formulated for application with primer or surface conditioner that complies with VOC limits of authorities having jurisdiction.

B. Adhesives for Gluing Furring and Sleepers to Concrete or Masonry: Formulation complying with ASTM D3498 that is approved for use indicated by adhesive manufacturer.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Framing Standard: Comply with AF&PA's WCD 1, "Details for Conventional Wood Frame Construction," unless otherwise indicated.

B. Framing with Engineered Wood Products: Install engineered wood products to comply with manufacturer's written instructions.

C. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry accurately to other construction. Locate furring, nailers, blocking, grounds, and similar supports to comply with requirements for attaching other construction.

D. Install shear wall panels to comply with manufacturer's written instructions.

E. Install metal framing anchors to comply with manufacturer's written instructions. Install fasteners through each fastener hole.

F. Do not splice structural members between supports unless otherwise indicated.

G. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

H. Where wood-preservative-treated lumber is installed adjacent to metal decking, install continuous flexible flashing separator between wood and metal decking.

I. Securely attach rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. Table 2304.9.1, "Fastening Schedule," in ICC's International Building Code (IBC).
2. ICC-ES evaluation report for fastener.

## 3.2 PROTECTION

A. Protect wood that has been treated with inorganic boron (SBX) from weather. If, despite protection, inorganic boron-treated wood becomes wet, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

B. Protect rough carpentry from weather. If, despite protection, rough carpentry becomes wet enough that moisture content exceeds that specified, apply EPA-registered borate treatment. Apply borate solution by spraying to comply with EPA-registered label.

END OF SECTION 061000

SECTION 070150.19 - PREPARATION FOR REROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Full tear-off of roof as indicated on Drawings.
   2. Re-cover preparation of roof areas indicated on Drawings.
   3. Removal of flashings and counterflashings.

1.2 PREINSTALLATION MEETINGS

A. Preliminary Roofing Conference: Before starting removal Work, conduct conference at Project site.

1.3 INFORMATIONAL SUBMITTALS

A. Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including exterior and interior finish surfaces, that might be misconstrued as having been damaged by reroofing operations.

   1. Submit before Work begins.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Approved by Owner for Installer to work on re-roofing.

1.5 FIELD CONDITIONS

A. Existing Roofing System: Ballasted EPDM roof.

B. Owner will not occupy building immediately below reroofing area.

C. Protect building to be reroofed, new and existing mechanical equipment, adjacent buildings, walkways, site improvements, exterior plantings, and landscaping from damage or soiling from reroofing operations.

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

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

F. Limit construction loads on existing roof areas to be reroofed to provide support for rooftop equipment wheel loads and for uniformly distributed loads.

G. Weather Limitations: Proceed with reroofing preparation only when existing and forecasted weather conditions permit Work to proceed without water entering existing roofing system or building.

1. Remove only as much roofing in one day as can be made watertight in the same day.

## PART 2 - PRODUCTS

### 2.1 AUXILIARY REROOFING MATERIALS

A. General: Use auxiliary reroofing preparation materials recommended by roofing system manufacturer for intended use and compatible with components of existing roofing system.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Seal or isolate windows that may be exposed to airborne substances created in removal of existing materials.

B. Shut off rooftop utilities and service piping before beginning the Work.

C. Test existing roof drains to verify that they are not blocked or restricted.

1. Immediately notify Architect of any blockages or restrictions.

D. Coordinate with Owner to shut down air-intake equipment in the vicinity of the Work.

1. Cover air-intake louvers before proceeding with reroofing work that could affect indoor air quality or activate smoke detectors in the ductwork.

E. During removal operations, have sufficient and suitable materials on-site to facilitate rapid installation of temporary protection in the event of unexpected rain.

### 3.2 ROOF TEAR-OFF

A. Notify Owner each day of extent of roof tear-off proposed for that day and obtain authorization to proceed.

B. Lower removed roofing materials to ground and onto lower roof levels, using dust-tight chutes or other acceptable means of removing materials from roof areas.

### 3.3 DECK PREPARATION

A. Inspect deck after tear-off of roofing system.

B. If broken or loose fasteners that secure deck panels to one another or to structure are observed, or if deck appears or feels inadequately attached, immediately notify Owner.

1. Do not proceed with installation until directed by Owner.

C. If deck surface is unsuitable for receiving new roofing or if structural integrity of deck is suspect, immediately notify Architect.

1. Do not proceed with installation until directed by Owner

D. Replace plywood roof sheathing as directed by Owner.

## 3.4 ROOF FLASHING REMOVAL

A. Remove existing flashings.

1. Clean substrates of contaminants, such as asphalt, sheet materials, dirt, and debris.

B. Do not damage metal counterflashings that are to remain.

1. Replace metal counterflashings damaged during removal with counterflashings as specified in Section 076200 "Sheet Metal Flashing and Trim."

END OF SECTION 070150.19

SECTION 072100 - THERMAL INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Extruded polystyrene foam-plastic board insulation.
2. Glass-fiber blanket insulation.
3. Glass-fiber board insulation.

B. Related Requirements:
1. Section 042000 "Unit Masonry" for insulation installed in masonry cells.
2. Section 070150.19 "Preparation for Reroofing" Section 075423 "Thermoplastic-Polyolefin (TPO) Roofing" for insulation specified as part of roofing construction.
3. Section 092900 "Gypsum Board" for sound attenuation blanket used as acoustic insulation.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. All materials shall meet the Buy American Build American Act 2021. Contractor shall provide documentation to substantiate adherence.

B. Installer's Certification: Listing type, manufacturer, and R-value of insulation installed in each element of the building thermal envelope.

1. For blown-in or sprayed fiberglass and cellulosic-fiber loose-fill insulation, indicate initial installed thickness, settled thickness, settled R-value, installed density, coverage area, and number of bags installed.
2. Sign, date, and post the certification in a conspicuous location on Project site.

C. Product Test Reports: For each product, for tests performed by a qualified testing agency.

D. Research Reports: For foam-plastic insulation, from ICC-ES.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect insulation materials from physical damage and from deterioration due to moisture, soiling, and other sources. Store inside and in a dry location. Comply with manufacturer's written instructions for handling, storing, and protecting during installation.

B. Protect foam-plastic board insulation as follows:

1. Do not expose to sunlight except to necessary extent for period of installation and concealment.
2. Protect against ignition at all times. Do not deliver foam-plastic board materials to Project site until just before installation time.
3. Quickly complete installation and concealment of foam-plastic board insulation in each area of construction.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Maximum flame-spread and smoke-developed indexes less than Class A, 25 and 450 when tested in accordance with ASTM E84.

B. Fire-Resistance Ratings: Comply with ASTM E119 or UL 263; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Indicate design designations from UL's "Fire Resistance Directory" or from listings of another qualified testing agency.

C. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

D. Labeling: Provide identification of mark indicating R-value of each piece of insulation 12 inches (305 mm) and wider in width.

E. Thermal-Resistance Value (R-Value): R-value as indicated on Drawings in accordance with ASTM C518.

### 2.2 EXTRUDED POLYSTYRENE FOAM-PLASTIC BOARD INSULATION (XPS)

A. Extruded Polystyrene Board Insulation, Type X : ASTM C578, Type X, 15 psi (104 kPa) minimum compressive strength; unfaced.

B. Extruded Polystyrene Board Insulation, Type IV : ASTM C578, Type IV, 25 psi (173 kPa) minimum compressive strength; unfaced.

C. Extruded Polystyrene Board Insulation, Type IV, Drainage Panels ASTM C578, Type IV, 25 psi (173 kPa) minimum compressive strength; unfaced.

D. Extruded Polystyrene Board Insulation, Type VI : ASTM C578, Type VI, 40 psi (276 kPa) minimum compressive strength.

E. Extruded Polystyrene Board Insulation, Type VI, Drainage Panels : ASTM C578, Type VI, 40 psi (276 kPa) minimum compressive strength; unfaced.

## 2.3 POLYISOCYANURATE FOAM-PLASTIC BOARD INSULATION

A. Polyisocyanurate Board Insulation, Glass-Fiber-Mat Faced : ASTM C1289, glass-fiber-mat faced, Type II, Class 2.

## 2.4 GLASS-FIBER BLANKET INSULATION

A. Glass-Fiber Blanket Insulation, Unfaced : ASTM C665, Type I; passing ASTM E136 for combustion characteristics.

B. Glass-Fiber Blanket Insulation, Polypropylene-Scrim-Kraft Faced : ASTM C665, Type II (nonreflective faced), Class A (faced surface with a flame-spread index of 25 or less); Category 1 (membrane is a vapor barrier).

## 2.5 GLASS-FIBER BOARD INSULATION

A. Glass-Fiber Board Insulation, Unfaced Insert drawing designation: ASTM C612, Type IA; unfaced, passing ASTM E136 for combustion characteristics.
   1. Nominal Density: 6 lb/cu. ft. (96 kg/cu. m).

B. Glass-Fiber Board Insulation, Faced : ASTM C612, Type IA; faced on one side with foil-scrim-kraft or foil-scrim-polyethylene vapor retarder.
   1. Nominal Density: 6 lb/cu. ft. (96 kg/cu. m).

## 2.6 INSULATION FASTENERS

A. Adhesively Attached, Spindle-Type Anchors: Plate welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

B. Adhesively Attached, Angle-Shaped, Spindle-Type Anchors: Angle welded to projecting spindle; capable of holding insulation of specified thickness securely in position with self-locking washer in place.

C. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- (0.41-mm-) thick galvanized-steel sheet, with beveled edge for increased stiffness, sized as required to hold insulation securely in place, but not less than 1-1/2 inches (38 mm) square or in diameter.

D. Anchor Adhesive: Product with demonstrated capability to bond insulation anchors securely to substrates without damaging insulation, fasteners, or substrates.

E. Insulation Fastener Accessories: Provide double-pointed weld pins, lagging pins, quilting pins, duct liner pins, insulation hangers, specialty washers, special caps, j-hooks, capacitor discharge annular weld pins, capacitor discharge acoustical lagging pins, and other accessory materials that are recommended in writing by insulation fastener manufacturer to produce complete insulation supports.

## 2.7 ACCESSORIES

A. Insulation for Miscellaneous Voids:

1. Glass-Fiber Insulation: ASTM C764, Type II, loose fill; with maximum flame-spread and smoke-developed indexes of 5, per ASTM E84.
2. Spray Polyurethane Foam Insulation: ASTM C1029, Type II, closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84.
3. Polyurethane Pour-In-Place Insulation: Closed cell, with maximum flame-spread and smoke-developed indexes of 75 and 450, respectively, per ASTM E84, specifically formulated for pour-in-place applications.

B. Miscellaneous Application Accessories:

1. Adhesive for Bonding Insulation: Product compatible with insulation and air and water barrier materials, and with demonstrated capability to bond insulation securely to substrates without damaging insulation and substrates.
2. Crack Sealer: Closed-cell insulating foam in aerosol dispenser recommended in writing by insulation manufacturer for filling gaps in board insulation.
3. Curtain-Wall Insulation Clips: Z-shaped galvanized steel as recommended in writing by insulation manufacturer.
4. Eave Ventilation Troughs: Preformed, rigid fiberboard or plastic sheets designed and sized to fit between roof framing members and to provide ventilation between insulated attic spaces and vented eaves.
5. Detailing Foam Insulation for Voids: Urethane foam complying with AAMA 812, low expansion pressure suitable for filling insulation gaps and voids adjacent to openings to protect against water, air, and sound intrusion.
6. Tapes for Reflective Insulation and Barriers:

   a. Aluminum-foil tape for repairs or splicing material.
   b. Double-sided tape for adhering to metal framing or overlapping material.
   c. Reinforced-foil tape for sealing tears or cuts in sheet vapor barrier.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Clean substrates of substances that are harmful to insulation, including removing projections capable of puncturing insulation or vapor retarders, or those that interfere with insulation attachment.

## 3.2 INSTALLATION, GENERAL

A. Comply with insulation manufacturer's written instructions applicable to products, applications and applicable codes.

B. Install insulation that is undamaged, dry, and unsoiled and that has not been left exposed to ice, rain, or snow at any time.

C. Install insulation with manufacturer's R-value label exposed after insulation is installed.

D. Extend insulation to envelop entire area to be insulated. Fit tightly around obstructions and fill voids with insulation. Remove projections that interfere with placement.

E. Provide sizes to fit applications and selected from manufacturer's standard thicknesses, widths, and lengths. Apply single layer of insulation units unless multiple layers are otherwise shown or required to make up total thickness or to achieve R-value.

## 3.3 INSTALLATION OF SLAB INSULATION

A. On horizontal surfaces, loosely lay insulation units in accordance with manufacturer's written instructions. Stagger end joints and tightly abut insulation units.

1. If not otherwise indicated, extend insulation a minimum of 24 inches (610 mm) in from exterior walls.

## 3.4 INSTALLATION OF FOUNDATION WALL INSULATION

A. Patch underslab insulation where damaged due to slab removal as necessary.

B. Butt panels together for tight fit.

C. Anchor Installation: Install board insulation on concrete substrates by adhesively attached, spindle-type insulation anchors as follows:

1. Fasten insulation anchors to concrete substrates with insulation anchor adhesive in accordance with anchor manufacturer's written instructions.
2. Space anchors in accordance with insulation manufacturer's written instructions for insulation type, thickness, and application.
3. Apply insulation standoffs to each spindle to create cavity width indicated on Drawings between concrete substrate and insulation.
4. After adhesive has dried, install board insulation by pressing insulation into position over spindles and securing it tightly in place with insulation-retaining washers, taking care not to compress insulation.
5. Where insulation will not be covered by other building materials, apply capped washers to tips of spindles.

D. Adhesive Installation: Install with adhesive or press into tacky waterproofing or dampproofing in accordance with manufacturer's written instructions.

## 3.5 INSTALLATION OF CAVITY-WALL INSULATION

A. Foam-Plastic Board Insulation: Install pads of adhesive spaced approximately 24 inches (610 mm) o.c. both ways on inside face and as recommended in writing by manufacturer.

1. Fit courses of insulation between wall ties and other obstructions, with edges butted tightly in both directions, and with faces flush.

2. Press units firmly against inside substrates.

## 3.6 INSTALLATION OF INSULATION IN FRAMED CONSTRUCTION

A. Blanket Insulation: Install in cavities formed by framing members in accordance with the following requirements:

1. Use insulation widths and lengths that fill the cavities formed by framing members. If more than one length is required to fill the cavities, provide lengths that will produce a snug fit between ends.
2. Place insulation in cavities formed by framing members to produce a friction fit between edges of insulation and adjoining framing members.
3. Maintain 3-inch (76-mm) clearance of insulation around recessed lighting fixtures not rated for or protected from contact with insulation.
4. For metal-framed wall cavities where cavity heights exceed 96 inches (2438 mm), support unfaced blankets mechanically and support faced blankets by taping flanges of insulation to flanges of metal studs.
5. Where glass-fiber blankets are indicated for sound attenuation above ceilings, install unfaced blanket insulation over ceiling area in thickness indicated. Where partitions occur, extend insulation up either side of partition.

    a. With faced blankets having stapling flanges, lap blanket flange over flange of adjacent blanket to maintain continuity of vapor retarder once finish material is installed over it.

    b. Exterior Walls: Set units with facing placed toward as indicated on Drawings.
    c. Interior Walls: Set units with facing placed as indicated on Drawings.

B. Miscellaneous Voids: Install insulation in miscellaneous voids and cavity spaces where required to prevent gaps in insulation using the following materials:

1. Glass-Fiber Insulation: Compact to approximately 40 percent of normal maximum volume equaling a density of approximately 2.5 lb/cu. ft. (40 kg/cu. m).
2. Detailing Foam Insulation for Voids: Apply in accordance with manufacturer's written instructions.

## 3.7 INSTALLATION OF BOARD INSULATION

A. Install board insulation in accordance with manufacturer's written instructions per project applications and conditions.

## 3.8 PROTECTION

A. Protect installed insulation from damage due to harmful weather exposures, physical abuse, and other causes.

B. Provide temporary coverings or enclosures where insulation is subject to abuse and cannot be concealed and protected by permanent construction immediately after installation.

END OF SECTION 072100

SECTION 072600 - VAPOR RETARDERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Polyethylene vapor retarders.

B. Related Requirements:

1. Section 033000 "Cast-in-Place Concrete" for under-slab vapor retarders.
2. Section 072100 "Thermal Insulation" for vapor retarders integral with insulation products.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2 - PRODUCTS

2.1 POLYETHYLENE VAPOR RETARDERS

A. Polyethylene Vapor Retarders: ASTM D4397 **10-mil- (0.25-mm-)** thick sheet, with maximum permeance rating of 0.1 perm (5.7 ng/Pa x s x sq. m).

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

a. ISI Building Products.
b. Reef Industries, Inc.
c. Viaflex.
d. W. R. Meadows, Inc.

PART 3 - EXECUTION

3.1 INSTALLATION OF VAPOR RETARDERS ON FRAMING

A. Extend vapor retarders to extremities of areas to protect from vapor transmission. Secure vapor retarders in place with adhesives, vapor retarder fasteners, or other anchorage system as recommended by manufacturer. Extend vapor retarders to cover miscellaneous voids in insulated substrates, including those filled with loose-fiber insulation.

B. Seal vertical joints in vapor retarders over framing by lapping no fewer than two studs and sealing with vapor-retarder tape according to vapor-retarder manufacturer's written instructions. Locate all joints over framing members or other solid substrates.

C. Seal joints caused by pipes, conduits, electrical boxes, and similar items penetrating vapor retarders with vapor-retarder tape to create an airtight seal between penetrating objects and vapor retarders.

D. Repair tears or punctures in vapor retarders immediately before concealment by other work. Cover with vapor-retarder tape or another layer of vapor retarders.

END OF SECTION 072600

SECTION 072713 - MODIFIED BITUMINOUS SHEET AIR BARRIERS

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes self-adhering, vapor-retarding, modified bituminous sheet air barriers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For air-barrier assemblies.

1. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of modified bituminous sheet air barrier.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturers.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Air-Barrier Performance: Air-barrier assembly and seals with adjacent construction to be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies to be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.2 L/s x sq. m of surface area at 75 Pa), when tested in accordance with ASTM E2357.

## 2.2 SELF-ADHERING SHEET AIR BARRIER

A. Modified Bituminous Sheet: 60-mil- (1.0-mm-) thick, self-adhering sheet consisting of 36 mils (0.9 mm) of rubberized asphalt laminated to a 4-mil- (0.1-mm-) thick, cross-laminated polyethylene film with release liner on adhesive side and formulated for application with primer that complies with VOC limits.

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

   a. Carlisle Coatings & Waterproofing Inc.
   b. Henry, a Carlisle Company (formerly Henry Company and Carlisle Coatings & Waterproofing Inc. brands).
   c. Polyguard Products, Inc.
   d. Tremco Incorporated.
   e. W. R. Meadows, Inc.

2. Physical and Performance Properties:

   a. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57-lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75-Pa) pressure difference; ASTM E2178.
   b. Tensile Strength: Minimum 250 psi (1.7 MPa); ASTM D412, Die C.
   c. Ultimate Elongation: Minimum 200 percent; ASTM D412, Die C.
   d. Puncture Resistance: Minimum 40 lbf (180 N); ASTM E154/E154M.
   e. Water Absorption: Maximum 0.15 percent weight gain after 48-hour immersion at 70 deg F (21 deg C); ASTM D570.
   f. Vapor Permeance: Maximum 0.1 perm (5.8 ng/Pa x s x sq. m); ASTM E96/E96M, Desiccant Method.
   g. Adhesion to Substrate: Minimum 16 lbf/sq. in. (110 kPa) when tested in accordance with ASTM D4541 as modified by ABAA.
   h. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

## 2.3 ACCESSORY MATERIALS

A. Requirement: Provide primers, transition strips, termination strips, joint sealants, counterflashing strips, flashing sheets and metal termination bars, termination mastic, substrate patching materials, adhesives, tapes, foam sealants, lap sealants, and other accessory materials that are recommended in writing by air-barrier manufacturer to produce a complete air-barrier assembly and that are compatible with primary air-barrier material and adjacent construction to which they may seal.

B. Primer: Liquid solvent-borne primer recommended for substrate by air-barrier material manufacturer.

PART 3 - EXECUTION

3.1 SURFACE PREPARATION

A. Clean, prepare, treat, fill, and seal substrate and joints and cracks in substrate in accordance with manufacturer's written instructions and details. Provide clean, dust-free, and dry substrate for air-barrier application.

B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.

C. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching membrane.

D. Remove excess mortar from masonry ties, shelf angles, and other obstructions.

E. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.

3.2 INSTALLATION

A. Install materials in accordance with air-barrier manufacturer's written instructions and details and in accordance with recommendations in ASTM D6135 to form a seal with adjacent construction and ensure continuity of air and water barrier.
   1. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.

B. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier sheet on same day. Reprime areas exposed for more than 24 hours.

C. Apply and firmly adhere air-barrier sheets over area to receive air barrier. Accurately align sheets and maintain uniform 2-1/2-inch- (64-mm-) minimum lap widths and end laps. Overlap and seal seams and stagger end laps to ensure airtight installation.

   1. Apply sheets in a shingled manner to shed water.
   2. Roll sheets firmly to enhance adhesion to substrate.

D. Install air-barrier sheet and accessory materials to form a seal with adjacent construction and to maintain a continuous air barrier.

E. Connect and seal exterior wall air-barrier sheet continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.

F. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition strip so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate. Maintain 3 inches (75 mm) of contact over firm bearing to perimeter frames, with not less than 1 inch (25 mm) of full contact.

G. Repair punctures, voids, and deficient lapped seams in air barrier. Slit and flatten fishmouths and blisters. Patch with air-barrier sheet extending 6 inches (150 mm) beyond repaired areas in all directions.

H. Do not cover air barrier until it has been tested and inspected by testing agency.

I. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

## 3.3 FIELD QUALITY CONTROL

A. Testing Agency: Architect/Engineer to review work on-site no less than once during construction.

B. Air barriers will be considered defective if they do not pass tests and inspections.

1. Apply additional air-barrier material, in accordance with manufacturer's written instructions, where inspection results indicate insufficient thickness.
2. Remove and replace deficient air-barrier components for retesting as specified above.

C. Repair damage to air barriers caused by testing; follow manufacturer's written instructions.

D. Prepare field reports.

## 3.4 CLEANING AND PROTECTION

A. Protect air-barrier system from damage during application and remainder of construction period, in accordance with manufacturer's written instructions.

END OF SECTION 072713

SECTION 072726 - FLUID-APPLIED MEMBRANE AIR BARRIERS

## 1.1 SUMMARY

A. Section Includes:
   1. Medium-build air barriers, vapor retarding.
   2. Medium-build air barriers, vapor permeable.

## 1.2 DEFINITIONS

A. Air-Barrier Accessory: A transitional component of the air barrier that provides continuity.

B. Air-Barrier Assembly: The collection of air-barrier materials and accessories applied to an opaque wall, including joints and junctions to abutting construction, to control air movement through the wall.

C. Air-Barrier Material: A primary element that provides a continuous barrier to the movement of air.

## 1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

   1. Review air-barrier requirements and installation, special details, mockups, air-leakage and bond testing, air-barrier protection, and work scheduling that covers air barriers.

## 1.4 ACTION SUBMITTALS

A. Product Data: Include manufacturer's written instructions for evaluating, preparing, and treating each substrate; technical data; dry film thickness; and tested physical and performance properties of products.
   1. Medium-build air barriers, vapor retarding.
   2. Medium-build air barriers, vapor permeable.

B. Shop Drawings: For air-barrier assemblies.

   1. Show locations and extent of air-barrier materials, accessories, and assemblies specific to Project conditions.
   2. Include details for substrate joints and cracks, counterflashing strips, penetrations, inside and outside corners, terminations, and tie-ins with adjoining construction.
   3. Include details of interfaces with other materials that form part of air barrier.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer. Include list of ABAA-certified installers and supervisors employed by Installer, who work on Project.

B. Product Certificates: From air-barrier manufacturer, certifying compatibility of air barriers and accessory materials with Project materials that connect to or that come in contact with the barrier.

C. Product Test Reports: For each air-barrier assembly, for tests performed by a qualified testing agency.

D. Field quality-control reports.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are trained and approved by manufacturer.

1. Installer to be licensed by ABAA in accordance with ABAA's Quality Assurance Program and to employ ABAA-certified installers and supervisors on Project.

B. Mockups: None

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Remove and replace liquid materials that cannot be applied within their stated shelf life.

B. Protect stored materials from direct sunlight.

## 1.8 FIELD CONDITIONS

A. Environmental Limitations: Apply air barrier within the range of ambient and substrate temperatures recommended in writing by air-barrier manufacturer.

1. Protect substrates from environmental conditions that affect air-barrier performance.
2. Do not apply air barrier to a damp or wet substrate or during snow, rain, fog, or mist.

# PART 2 - PRODUCTS

## 2.1 SOURCE LIMITATIONS

A. Obtain primary air-barrier materials and air-barrier accessories from single manufacturer.

## 2.2 PERFORMANCE REQUIREMENTS

A. Air-Barrier Performance: Air-barrier assembly and seals with adjacent construction to be capable of performing as a continuous air barrier and as a liquid-water drainage plane flashed to discharge to the exterior incidental condensation or water penetration. Air-barrier assemblies to be capable of accommodating substrate movement and of sealing substrate expansion and control joints, construction material changes, penetrations, tie-ins to installed waterproofing,

and transitions at perimeter conditions without deterioration and air leakage exceeding specified limits.

B. Air-Barrier Assembly Air Leakage: Maximum 0.04 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.2 L/s x sq. m of surface area at 75 Pa), when tested in accordance with ASTM E2357.

C. Air Permeance: Maximum 0.004 cfm/sq. ft. of surface area at 1.57 lbf/sq. ft. (0.02 L/s x sq. m of surface area at 75 Pa) pressure difference; ASTM E2178.

D. Ultimate Elongation: Minimum 200 percent; ASTM D412, Die C.

E. Adhesion to Substrate: Minimum 16 lbf/sq. in. (110 kPa) when tested in accordance with ASTM D4541.

F. Fire Propagation Characteristics: Passes NFPA 285 testing as part of an approved assembly.

G. UV Resistance: Can be exposed to sunlight for 30 days in accordance with manufacturer's written instructions.

## 2.3 MEDIUM-BUILD AIR BARRIERS, VAPOR RETARDING

A. Medium-Build, Vapor-Retarding Air Barrier: Synthetic polymer material with an installed dry film thickness, according to manufacturer's written instructions, of 16 to 34 mils (0.41 to 0.86 mm) over smooth, void-free substrates.
   1. Vapor Permeance: Maximum 0.1 perm (5.8 ng/Pa x s x sq. m); ASTM E96/E96M, Procedure A, Desiccant Method.

## 2.4 MEDIUM-BUILD AIR BARRIERS, VAPOR PERMEABLE

A. Medium-Build, Vapor-Permeable Air Barrier: Synthetic polymer material with an installed dry film thickness, according to manufacturer's written instructions, of 16 to 34 mils (0.41 to 0.86 mm) over smooth, void-free substrates.
   1. Vapor Permeance: Minimum 5 perms (290 ng/Pa x s x sq. m); ASTM E96/E96M, Procedure A, Desiccant Method.

## 2.5 ACCESSORY MATERIALS

A. Provide primers, transition strips, termination strips, joint reinforcing fabric and strips, joint sealants, counterflashing strips, flashing sheets and metal termination bars, termination mastic, substrate patching materials, adhesives, tapes, foam sealants, lap sealants, and other accessory materials that are recommended in writing by air-barrier manufacturer to produce a complete air-barrier assembly and that are compatible with primary air-barrier material and adjacent construction to which they may seal.

B. Primer: Liquid primer recommended for substrate by air-barrier material manufacturer.

C. Preformed Silicone Extrusion: Manufacturer's standard system consisting of cured low-modulus silicone extrusion, sized to fit opening widths, with a single-component, neutral-curing, Class 100/50 (low-modulus) silicone sealant for bonding extrusions to substrates.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

1. Verify that substrates are sound and free of oil, grease, dirt, excess mortar, or other contaminants.
2. Verify that substrates have cured and aged for minimum time recommended in writing by air-barrier manufacturer.
3. Verify that masonry joints are flush and completely filled with mortar.

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

### 3.2 SURFACE PREPARATION

A. Clean, prepare, treat, fill, and seal substrate and joints and cracks in substrate in accordance with manufacturer's written instructions and details. Provide clean, dust-free, and dry substrate for air-barrier application.

B. Mask off adjoining surfaces not covered by air barrier to prevent spillage and overspray affecting other construction.

C. Remove grease, oil, bitumen, form-release agents, paints, curing compounds, and other penetrating contaminants or film-forming coatings from concrete.

D. Remove fins, ridges, mortar, and other projections and fill honeycomb, aggregate pockets, holes, and other voids in concrete with substrate-patching material.

E. Remove excess mortar from masonry ties, shelf angles, and other obstructions.

F. At changes in substrate plane, apply sealant or termination mastic beads at sharp corners and edges to form a smooth transition from one plane to another.

G. Cover gaps in substrate plane and form a smooth transition from one substrate plane to another with stainless steel sheet mechanically fastened to structural framing to provide continuous support for air barrier.

H. Bridge isolation joints, expansion joints and discontinuous wall-to-wall, deck-to-wall, and deck-to-deck joints with air-barrier accessory material that accommodates joint movement in accordance with manufacturer's written instructions and details.

### 3.3 INSTALLATION OF ACCESSORIES

A. Install accessory materials in accordance with air-barrier manufacturer's written instructions and details to form a seal with adjacent construction and ensure continuity of air and water barrier.

1. Coordinate the installation of air barrier with installation of roofing membrane and base flashing to ensure continuity of air barrier with roofing membrane.
2. Install transition strip on roofing membrane or base flashing so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate.
3. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
4. Apply primer to substrates at required rate and allow it to dry. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.

B. Connect and seal exterior wall air-barrier material continuously to roofing-membrane air barrier, concrete below-grade structures, floor-to-floor construction, exterior glazing and window systems, glazed curtain-wall systems, storefront systems, exterior louvers, exterior door framing, and other construction used in exterior wall openings, using accessory materials.

C. At end of each working day, seal top edge of strips and transition strips to substrate with termination mastic.

D. Apply joint sealants forming part of air-barrier assembly within manufacturer's recommended application temperature ranges. Consult manufacturer when sealant cannot be applied within these temperature ranges.

E. Wall Openings: Prime concealed, perimeter frame surfaces of windows, curtain walls, storefronts, and doors. Apply transition strip so that a minimum of 3 inches (75 mm) of coverage is achieved over each substrate. Maintain 3 inches (75 mm) of full contact over firm bearing to perimeter frames, with not less than 1 inch (25 mm) of full contact.

1. Transition Strip: Roll firmly to enhance adhesion.

F. Fill gaps in perimeter frame surfaces of windows, curtain walls, storefronts, and doors, and miscellaneous penetrations of air-barrier material with foam sealant.

G. Seal strips and transition strips around masonry reinforcing or ties and penetrations with termination mastic.

H. Seal top of through-wall flashings to air barrier with an additional 6-inch- (150-mm-) wide, transition strip.

I. Seal exposed edges of strips at seams, cuts, penetrations, and terminations not concealed by metal counterflashings or ending in reglets with termination mastic.

J. Repair punctures, voids, and deficient lapped seams in strips and transition strips. Slit and flatten fishmouths and blisters. Patch with transition strips extending 6 inches (150 mm) beyond repaired areas in strip direction.

## 3.4 INSTALLATION OF PRIMARY AIR-BARRIER MATERIAL

A. Apply air-barrier material to form a seal with strips and transition strips and to achieve a continuous air barrier in accordance with air-barrier manufacturer's written instructions and details. Apply air-barrier material within manufacturer's recommended application temperature ranges.

1. Unless manufacturer recommends in writing against priming, apply primer to substrates at required rate and allow it to dry.
2. Limit priming to areas that will be covered by air-barrier material on same day. Reprime areas exposed for more than 24 hours.
3. Where multiple prime coats are needed to achieve required bond, allow adequate drying time between coats.

B. High-Build Air Barriers: Apply continuous unbroken air-barrier material to substrates according to the following thickness. Apply air-barrier material in full contact around protrusions such as masonry ties.

C. Medium-Build Air Barriers: Apply continuous unbroken air-barrier material to substrates according to the following thickness. Apply an increased thickness of air-barrier material in full contact around protrusions such as masonry ties.

1. Vapor-Retarding, Medium-Build Air Barrier: Total dry film thickness as recommended in writing by manufacturer to comply with performance requirements, applied in one or more equal coats. Apply additional material as needed to achieve void- and pinhole-free surface.
2. Vapor-Permeable, Medium-Build Air Barrier: Total dry film thickness as recommended in writing by manufacturer to comply with performance requirements applied in one or more equal coats. Apply additional material as needed to achieve void- and pinhole-free surface, but do not exceed thickness on which required vapor permeability is based.

D. Do not cover air barrier until it has been tested and inspected by testing agency.

E. Correct deficiencies in or remove air barrier that does not comply with requirements; repair substrates and reapply air-barrier components.

## 3.5 FIELD QUALITY CONTROL

A. ABAA Quality Assurance Program: Perform examinations, preparation, installation, testing, and inspections under ABAA's Quality Assurance Program.

B. Inspections: Architect/Engineer to perform field inspections. Air-barrier materials, accessories, and installation are subject to inspection for compliance with requirements. Inspections may include the following:

1. Continuity of air-barrier system has been achieved throughout the building envelope with no gaps or holes.
2. Air-barrier dry film thickness.
3. Continuous structural support of air-barrier system has been provided.
4. Masonry and concrete surfaces are smooth, clean, and free of cavities, protrusions, and mortar droppings.
5. Site conditions for application temperature and dryness of substrates have been maintained.
6. Maximum exposure time of materials to UV deterioration has not been exceeded.
7. Surfaces have been primed, if applicable.
8. Laps in strips and transition strips have complied with minimum requirements and have been shingled in the correct direction (or mastic has been applied on exposed edges), with no fishmouths.

9. Termination mastic has been applied on cut edges.
10. Strips and transition strips have been firmly adhered to substrate.
11. Compatible materials have been used.
12. Transitions at changes in direction and structural support at gaps have been provided.
13. Connections between assemblies (air-barrier and sealants) have complied with requirements for cleanliness, surface preparation and priming, structural support, integrity, and continuity of seal.
14. All penetrations have been sealed.

C. Air barriers will be considered defective if they do not pass Architect/Engineer inspections.

1. Apply additional air-barrier material, in accordance with manufacturer's written instructions, where inspection results indicate insufficient thickness.
2. Remove and replace deficient air-barrier components for retesting as specified above.

D. Repair damage to air barriers; follow manufacturer's written instructions.

E. Prepare test and inspection reports.

3.6 CLEANING AND PROTECTION

A. Protect air-barrier system from damage during application and remainder of construction period, in accordance with manufacturer's written instructions.

1. Protect air barrier from exposure to UV light and harmful weather exposure as recommended in writing by manufacturer. If exposed to these conditions for longer than recommended, remove and replace air barrier or install additional, full-thickness, air-barrier application after repairing and preparing the overexposed materials in accordance with air-barrier manufacturer's written instructions.
2. Protect air barrier from contact with incompatible materials and sealants not approved by air-barrier manufacturer.

B. Clean spills, stains, and soiling from construction that would be exposed in the completed work using cleaning agents and procedures recommended in writing by manufacturer of affected construction.

C. Remove masking materials after installation.

END OF SECTION 072726

SECTION 075423 - THERMOPLASTIC-POLYOLEFIN (TPO) ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Thermoplastic polyolefin (TPO) roofing system.
2. Accessory roofing materials.
3. Substrate board.
4. Vapor retarder.
5. Roof insulation.
6. Insulation accessories and cover board.

B. Section includes installation of sound-absorbing insulation strips in ribs of roof deck. Sound-absorbing insulation strips are furnished under Section 053100 "Steel Decking."

C. Related Requirements:
1. Section 061000 "Rough Carpentry" for wood nailers, curbs, and blocking; and for wood-based, structural-use roof deck panels.
2. Section 061600 "Sheathing" for wood-based, structural-use roof deck panels.
3. Section 072100 "Thermal Insulation" for insulation beneath the roof deck.
4. Section 076200 "Sheet Metal Flashing and Trim" for metal roof flashings and counterflashings.
5. Section 078443 "Roof Accessories" for manufactured copings and roof edge flashings.
6. Section 079200 "Joint Sealants" for joint sealants, joint fillers, and joint preparation.

1.2 DEFINITIONS

A. Roofing Terminology: Definitions in ASTM D1079 and glossary in NRCA's "The NRCA Roofing Manual: Membrane Roof Systems" apply to Work of this Section.

1.3 PREINSTALLATION MEETINGS

A. All materials shall meet the Buy American Build American Act 2021. Contractor shall provide documentation to substantiate adherence.

B. Preliminary Roofing Conference: Before starting roof deck construction, conduct conference at Project site.

1. Meet with Owner, Architect, Construction Manager, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, air barrier Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.

2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review deck substrate requirements for conditions and finishes, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

C. Preinstallation Roofing Conference: Conduct conference at Project site.

1. Meet with Owner, Architect, Construction Manager, Owner's insurer if applicable, testing and inspecting agency representative, roofing Installer, roofing system manufacturer's representative, deck Installer, air barrier Installer, and installers whose work interfaces with or affects roofing, including installers of roof accessories and roof-mounted equipment.
2. Review methods and procedures related to roofing installation, including manufacturer's written instructions.
3. Review and finalize construction schedule, and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Examine deck substrate conditions and finishes for compliance with requirements, including flatness and fastening.
5. Review structural loading limitations of roof deck during and after roofing.
6. Review base flashings, special roofing details, roof drainage, roof penetrations, equipment curbs, and condition of other construction that affects roofing system.
7. Review governing regulations and requirements for insurance and certificates if applicable.
8. Review temporary protection requirements for roofing system during and after installation.
9. Review roof observation and repair procedures after roofing installation.

## 1.4 ACTION SUBMITTALS

A. Product Data:

1. Thermoplastic polyolefin (TPO) roofing system.
2. Accessory roofing materials.
3. Substrate board.
4. Vapor retarder.
5. Roof insulation.
6. Insulation accessories and cover board.
7. Electronic leak detection (ELD) materials.

B. For insulation and roof system component fasteners, include copy of FM Approvals' RoofNav listing.

C. Shop Drawings: Include roof plans, sections, details, and attachments to other work, including the following:

1. Layout and thickness of insulation.
2. Base flashings and membrane termination details.
3. Flashing details at penetrations.
4. Tapered insulation layout, thickness, and slopes.
5. Roof plan showing orientation of steel roof deck and orientation of roof membrane, fastening spacings, and patterns for mechanically fastened roofing system.
6. Insulation fastening patterns for corner, perimeter, and field-of-roof locations.
7. Tie-in with adjoining air barrier.

D. Samples for Verification: For the following products:

1. Roof membrane and flashings, of color required.

E. Wind Uplift Resistance Submittal: For roofing system, indicating compliance with wind uplift performance requirements.

## 1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer and testing agency.

B. Manufacturer Certificates:

1. Performance Requirement Certificate: Signed by roof membrane manufacturer, certifying that roofing system complies with requirements specified in "Performance Requirements" Article.

a. Submit evidence of compliance with performance requirements.

2. Special Warranty Certificate: Signed by roof membrane manufacturer, certifying that all materials supplied under this Section are acceptable for special warranty.

C. Product Test Reports: For roof membrane and insulation, for tests performed by a qualified testing agency, indicating compliance with specified requirements.

D. Evaluation Reports: For components of roofing system, from ICC-ES.

E. Field Test Reports:
1. Fastener-pullout test results and manufacturer's revised requirements for fastener patterns.

F. Field quality-control reports.

G. Sample Warranties: For manufacturer's special warranties.

## 1.6 CLOSEOUT SUBMITTALS

A. Maintenance Data: For roofing system to include in maintenance manuals.

B. Certified statement from existing roof membrane manufacturer stating that existing roof warranty has not been affected by Work performed under this Section.

## 1.7 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer that is listed in FM Approvals' RoofNav for roofing system identical to that used for this Project.

B. Installer Qualifications: A qualified firm that is approved, authorized, or licensed by roofing system manufacturer to install manufacturer's product and that is eligible to receive manufacturer's special warranty.

## 1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver roofing materials to Project site in original containers with seals unbroken and labeled with manufacturer's name, product brand name and type, date of manufacture, approval or listing agency markings, and directions for storing and mixing with other components.

B. Store liquid materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by roofing system manufacturer. Protect stored liquid material from direct sunlight.

1. Discard and legally dispose of liquid material that cannot be applied within its stated shelf life.

C. Protect roof insulation materials from physical damage and from deterioration by sunlight, moisture, soiling, and other sources. Store in a dry location. Comply with insulation manufacturer's written instructions for handling, storing, and protecting during installation.

D. Handle and store roofing materials, and place equipment in a manner to avoid permanent deflection of deck.

## 1.9 FIELD CONDITIONS

A. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit roofing system to be installed according to manufacturer's written instructions and warranty requirements.

## 1.10 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of roofing system that fail in materials or workmanship within specified warranty period.

1. Special warranty includes roof membrane, base flashings, roof insulation, fasteners, cover boards, vapor retarder, substrate board] and other components of roofing system.
2. Warranty Period: 30 years from date of Substantial Completion.

B. Special Project Warranty: Submit roofing Installer's warranty, on warranty form at end of this Section, signed by Installer, covering the Work of this Section, including all components of roofing system such as roof membrane, base flashing, roof insulation, fasteners, cover boards, substrate boards, vapor retarders, and walkway products, for the following warranty period:

1. Warranty Period: Two years from date of Substantial Completion.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Installed roofing system and flashings to withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Roof system and flashings to remain watertight.

1. Accelerated Weathering: Roof to withstand 2000 hours of exposure when tested according to ASTM G152, ASTM G154, or ASTM G155.
2. Impact Resistance: Roof membrane to resist impact damage when tested according to ASTM D3746, ASTM D4272, or the "Resistance to Foot Traffic Test" in FM Approvals 4470.

B. Material Compatibility: Roofing materials to be compatible with one another and adjacent materials under conditions of service and application required, as demonstrated by roof membrane manufacturer based on testing and field experience.

C. Wind Uplift Resistance: Design roofing system to resist the wind uplift pressures as shown on the structural drawings when tested according to FM Approvals 4474, UL 580, or UL 1897:

D. FM Approvals' RoofNav Listing: Roof membrane, base flashings, and component materials comply with requirements in FM Approvals 4450 or FM Approvals 4470 as part of a roofing system and are listed in FM Approvals' RoofNav for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals Certification markings.

1. Fire/Windstorm Classification: Class 1A-105.
2. Hail-Resistance Rating: FM Global Property Loss Prevention Data Sheet 1-34 MH.

E. SPRI's Directory of Roof Assemblies Listing: Roof membrane, base flashings, and component materials comply with requirements in FM Approvals 4450 or FM Approvals 4470 as part of a roofing system, and are listed in SPRI's Directory of Roof Assemblies for roof assembly identical for that specified for this Project.

1. Wind Uplift Load Capacity: 105 psf

F. Energy Performance: Roofing system to have an initial solar reflectance of not less than 0.70 and an emissivity of not less than 0.75 when tested in accordance with ANSI/CRRC S100.

G. Exterior Fire-Test Exposure: ASTM E108 or UL 790, Class A; for application and roof slopes indicated; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

H. Fire-Resistance Ratings: Comply with fire-resistance-rated assembly designs indicated. Identify products with appropriate markings of applicable testing agency.

## 2.2 THERMOPLASTIC POLYOLEFIN (TPO) ROOFING SYSTEM

A. TPO Sheet: ASTM D6878/D6878M, internally fabric- or scrim-reinforced, self-adhering TPO sheet.
   1. Source Limitations: Obtain components for roofing system from roof membrane manufacturer or manufacturers approved by roof membrane manufacturer.
   2. Thickness: 60 mils (1.5 mm) nominal.
   3. Exposed Face Color: White.

## 2.3 ACCESSORY ROOFING MATERIALS

A. General: Accessory materials recommended by roofing system manufacturer for intended use and compatible with other roofing components.

   1. Adhesive and Sealants: Comply with VOC limits of authorities having jurisdiction.

B. Sheet Flashing: Manufacturer's standard unreinforced TPO sheet flashing, 55 mils (1.4 mm) thick, minimum, of same color as TPO sheet.

C. Prefabricated Pipe Flashings: As recommended by roof membrane manufacturer.

D. Roof Vents: As recommended by roof membrane manufacturer.

   1. Size: Not less than 4-inch (100-mm) diameter.

E. Bonding Adhesive: Manufacturer's standard, water based.

F. Slip Sheet: Manufacturer's standard, of thickness required for application.

G. Asphalt-Coated, Glass-Fiber-Mat, Venting Base Sheet: ASTM D4897/D4897M, Type II; nonperforated, asphalt-impregnated fiberglass reinforced, with mineral granular patterned surfacing on bottom surface.

H. Metal Termination Bars: Manufacturer's standard, predrilled stainless steel or aluminum bars, approximately 1 by 1/8 inch (25 by 3 mm) thick; with anchors.

I. Metal Battens: Manufacturer's standard, aluminum-zinc-alloy-coated or zinc-coated steel sheet, approximately 1 inch wide by 0.05 inch thick (25 mm wide by 1.3 mm thick), prepunched.

J. Ballast Retaining Bar: Perimeter securement system consisting of a slotted extruded-aluminum retention bar with an integrated compression fastening strip.

1. Fasteners: 1-1/2-inch (38-mm) stainless steel fasteners with neoprene washers.

K. Fasteners: Factory-coated steel fasteners and metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roofing components to substrate, and acceptable to roofing system manufacturer.

L. Miscellaneous Accessories: Provide pourable sealers, preformed cone and vent sheet flashings, preformed inside and outside corner sheet flashings, T-joint covers, lap sealants, termination reglets, and other accessories.

## 2.4 ROOF INSULATION

A. Polyisocyanurate Board Insulation: ASTM C1289, Type II, Class 2, Grade, felt or glass-fiber mat facer on both major surfaces.
1. Compressive Strength: 20 psi (138 kPa).
2. Size: 48 by 48 inches (1219 by 1219 mm).
3. Thickness:

a. Base Layer: 1-1/2 inches (38 mm).
b. Upper Layer: varies, 4” average.

B. Tapered Insulation: Provide factory-tapered insulation boards for low-roof area.

1. Material: Match roof insulation.
2. Minimum Thickness: 1/4 inch (6.35 mm).
3. Slope:

a. Roof Field: 1/4 inch per foot (1:48) unless otherwise indicated on Drawings.
b. Saddles and Crickets: 1/2 inch per foot (1:24) unless otherwise indicated on Drawings.

## 2.5 INSULATION ACCESSORIES AND COVER BOARD

A. General: Roof insulation accessories recommended by insulation manufacturer for intended use and compatibility with other roofing system components.

B. Fasteners: Factory-coated steel fasteners with metal or plastic plates complying with corrosion-resistance provisions in FM Approvals 4470, designed for fastening roof insulation and cover boards to substrate, and acceptable to roofing system manufacturer.

C. Insulation Adhesive: Insulation manufacturer's recommended adhesive formulated to attach roof insulation to substrate or to another insulation layer as follows:

1. Modified asphaltic, asbestos-free, cold-applied adhesive.

D. Glass-Mat Gypsum Cover Board: ASTM C1177/C1177M, water-resistant gypsum board.

2. Thickness: 5/8 inch (16 mm).
3. Surface Finish: Factory primed.

E. Protection Mat: Woven or nonwoven polypropylene, polyolefin, or polyester fabric; water permeable and resistant to UV degradation; type and weight as recommended by roofing system manufacturer for application.

## 2.6 ASPHALT MATERIALS

A. Roofing Asphalt: ASTM D312/D312M, Type III or Type IV.

B. Asphalt Primer: ASTM D41/D41M.

## 2.7 WALKWAYS

A. Flexible Walkways: Factory-formed, nonporous, heavy-duty, slip-resisting, surface-textured walkway pads, approximately 3/16 inch (5 mm) thick and acceptable to roofing system manufacturer.

1. Size: Approximately 36 by 60 inches (914 by 1524 mm).
2. Color: Contrasting with roof membrane.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.

1. Verify that roof openings and penetrations are in place, curbs are set and braced, and roof-drain bodies are securely clamped in place.
2. Verify that wood blocking, curbs, and nailers are securely anchored to roof deck at penetrations and terminations and that nailers match thicknesses of insulation.
3. Verify that minimum concrete drying period recommended by roofing system manufacturer has passed.
4. Verify that concrete substrate is visibly dry and free of moisture, and that minimum concrete internal relative humidity is not more than 75 percent, or as recommended by roofing system manufacturer, when tested according to ASTM F2170.

   a. Test Frequency: One test probe per each 1000 sq. ft. (93 sq. m), or portion thereof, of roof deck, with not less than three tests probes.
   b. Submit test reports within 24 hours after performing tests.

5. Verify that concrete-curing compounds that will impair adhesion of roofing components to roof deck have been removed.
6. Verify that joints in precast concrete roof decks have been grouted flush with top of concrete.

7. Verify that minimum curing period recommended by roofing system manufacturer for lightweight insulating concrete roof decks has passed.

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

## 3.2 PREPARATION

A. Clean substrate of dust, debris, moisture, and other substances detrimental to roofing system installation according to roofing system manufacturer's written instructions. Remove sharp projections.

B. Prevent materials from entering and clogging roof drains and conductors and from spilling or migrating onto surfaces of other construction. Remove roof-drain plugs when no work is taking place or when rain is forecast.

C. Perform fastener-pullout tests according to roof system manufacturer's written instructions.

1. Submit test result within 24 hours after performing tests.

a. Include manufacturer's requirements for any revision to previously submitted fastener patterns required to achieve specified wind uplift requirements.

## 3.3 INSTALLATION OF ROOFING, GENERAL

A. Install roofing system according to roofing system manufacturer's written instructions, FM Approvals' RoofNav listed roof assembly requirements, and FM Global Property Loss Prevention Data Sheet 1-29.

B. Complete terminations and base flashings and provide temporary seals to prevent water from entering completed sections of roofing system at end of workday or when rain is forecast. Remove and discard temporary seals before beginning Work on adjoining roofing.

C. Install roof membrane and auxiliary materials to tie in to existing roofing to maintain weathertightness of transition and to not void warranty for existing roofing system.

## 3.4 INSTALLATION OF SUBSTRATE BOARD

A. Install substrate board with long joints in continuous straight lines, with end joints staggered not less than 24 inches (610 mm) in adjacent rows.

1. Tightly butt substrate boards together.
2. Cut substrate board to fit tight around penetrations and projections, and to fit tight to intersecting sloping roof decks.
3. Fasten substrate board to top flanges of steel deck according to recommendations in FM Approvals' RoofNav listed roof assembly requirements for specified Windstorm Resistance Classification and FM Global Property Loss Prevention Data Sheet 1-29.
4. Fasten substrate board to top flanges of steel deck to resist uplift pressure at corners, perimeter, and field of roof according to roofing system manufacturers' written instructions.

## 3.5 INSTALLATION OF VAPOR RETARDER

A. Self-Adhering-Sheet Vapor Retarder: Prime substrate if required by manufacturer. Install self-adhering-sheet vapor retarder over area to receive vapor retarder, side and end lapping each sheet a minimum of 3-1/2 and 6 inches (90 and 150 mm), respectively.

1. Extend vertically up parapet walls and projections to a minimum height equal to height of insulation and cover board.
2. Seal laps by rolling.

B. Completely seal vapor retarder at terminations, obstructions, and penetrations to prevent air movement into roofing system.

## 3.6 INSTALLATION OF INSULATION

A. Coordinate installing roofing system components so insulation is not exposed to precipitation or left exposed at end of workday.

B. Comply with roofing system and roof insulation manufacturer's written instructions for installing roof insulation.

C. Installation Over Metal Decking:

1. Install base layer of insulation with joints staggered not less than 24 inches (610 mm) in adjacent rows and with long joints continuous at right angle to flutes of decking.

a. Locate end joints over crests of decking.
b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
c. Make joints between adjacent insulation boards not more than 1/4 inch (6 mm) in width.
d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches (610 mm).

1) Trim insulation so that water flow is unrestricted.

e. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
f. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.

1) Fasten insulation according to requirements in FM Approvals' RoofNav for specified Windstorm Resistance Classification
2) Fasten insulation to resist specified uplift pressure at corners, perimeter, and field of roof.

2. Install upper layers of insulation and tapered insulation with joints of each layer offset not less than 12 inches (305 mm) from previous layer of insulation.

a. Staggered end joints within each layer not less than 24 inches (610 mm) in adjacent rows.

b. Trim insulation neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
c. Make joints between adjacent insulation boards not more than 1/4 inch (6 mm) in width.
d. At internal roof drains, slope insulation to create a square drain sump with each side equal to the diameter of the drain bowl plus 24 inches (610 mm).

    1) Trim insulation so that water flow is unrestricted.

e. Fill gaps exceeding 1/4 inch (6 mm) with insulation.
f. Cut and fit insulation within 1/4 inch (6 mm) of nailers, projections, and penetrations.
g. Adhere each layer of insulation to substrate using adhesive according to FM Approvals' RoofNav listed roof assembly requirements for specified Windstorm Resistance Classification] and FM Global Property Loss Prevention Data Sheet 1-29, as follows:

    1) Set each layer of insulation in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
    2) Set each layer of insulation in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

## 3.7 INSTALLATION OF COVER BOARDS

A. Install cover boards over insulation with long joints in continuous straight lines with end joints staggered between rows. Offset joints of insulation below a minimum of 6 inches (150 mm) in each direction.

1. Trim cover board neatly to fit around penetrations and projections, and to fit tight to intersecting sloping roof decks.
2. At internal roof drains, conform to slope of drain sump.

    a. Trim cover board so that water flow is unrestricted.

3. Cut and fit cover board tight to nailers, projections, and penetrations.
4. Adhere cover board to substrate using adhesive according to FM Approvals' RoofNav listed roof assembly requirements for specified Windstorm Resistance Classificationand FM Global Property Loss Prevention Data Sheet 1-29, as follows:

    a. Set cover board in a solid mopping of hot roofing asphalt, applied within plus or minus 25 deg F (14 deg C) of equiviscous temperature.
    b. Set cover board in ribbons of bead-applied insulation adhesive, firmly pressing and maintaining insulation in place.
    c. Set cover board in a uniform coverage of full-spread insulation adhesive, firmly pressing and maintaining insulation in place.

B. Install slip sheet over cover board and beneath roof membrane.

## 3.8 INSTALLATION OF SELF-ADHERING ROOF MEMBRANE

A. Adhere roof membrane over area to receive roofing according to roofing system manufacturer's written instructions.

B. Unroll roof membrane and allow to relax before installing.

C. Start installation of roofing in presence of roofing system manufacturer's technical personnel.

D. Accurately align roof membrane, and maintain uniform side and end laps of minimum dimensions required by manufacturer.

   1. Stagger end laps.

E. Fold roof membrane to expose half of sheet width's bottom surface.

   1. Remove release liner on exposed half of sheet.
   2. Roll roof membrane over substrate while avoiding wrinkles.

F. Fold remaining half of roof membrane to expose bottom surface.

   1. Remove release liner on exposed half of sheet.
   2. Roll roof membrane over substrate while avoiding wrinkles.

G. In addition to adhering, mechanically fasten roof membrane securely at terminations, penetrations, and perimeter of roofing.

H. Apply roof membrane with side laps shingled with slope of roof deck where possible.

I. Seams: Clean seam areas, overlap roof membrane, and hot-air weld side and end laps of roof membrane and sheet flashings, to ensure a watertight seam installation.

   1. Test lap edges with probe to verify seam weld continuity.
   2. Apply lap sealant to seal cut edges of roof membrane and flashing sheet.
   3. Verify field strength of seams a minimum of twice daily, and repair seam sample areas.
   4. Repair tears, voids, and lapped seams in roof membrane that do not comply with requirements.

J. Spread sealant bed over deck-drain flange at roof drains, and securely seal roof membrane in place with clamping ring.

   1.

## 3.9 INSTALLATION OF BASE FLASHING

A. Install sheet flashings and preformed flashing accessories, and adhere to substrates according to roofing system manufacturer's written instructions.

B. Apply bonding adhesive to substrate and underside of sheet flashing at required rate, and allow to partially dry. Do not apply to seam area of flashing.

C. Flash penetrations and field-formed inside and outside corners with cured or uncured sheet flashing.

D. Clean seam areas, overlap, and firmly roll sheet flashings into the adhesive. Hot-air weld side and end laps to ensure a watertight seam installation.

E. Terminate and seal top of sheet flashings and mechanically anchor to substrate through termination bars.

## 3.10 INSTALLATION OF WALKWAYS

A. Flexible Walkways:

1. Install flexible walkways at the following locations:

   a. Retain one or more subparagraphs below. Revise to suit Project.
   b. Perimeter of each rooftop unit.
   c. Between each rooftop unit location, creating a continuous path connecting rooftop unit locations.
   d. Between each roof hatch and each rooftop unit location or path connecting rooftop unit locations.
   e. Top and bottom of each roof access ladder.
   f. Between each roof access ladder and each rooftop unit location or path connecting rooftop unit locations.
   g. Locations indicated on Drawings.
   h. As required by roof membrane manufacturer's warranty requirements.

2. Provide 6-inch (76-mm) clearance between adjoining pads.
3. Heat weld to substrate or adhere walkway products to substrate with compatible adhesive according to roofing system manufacturer's written instructions.

## 3.11 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified third-party inspector to perform tests and to inspect substrate conditions, surface preparation, roof membrane application, sheet flashings, protection, and drainage components, and to furnish reports to Architect.

B. Perform the following tests:

C. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion, in presence of Architect, and to prepare inspection report.

D. Repair or remove and replace components of roofing system where inspections indicate that they do not comply with specified requirements.

E. Additional testing and inspecting, at Contractor's expense, will be performed to determine if replaced or additional work complies with specified requirements.

3.12 PROTECTING AND CLEANING

A. Protect roofing system from damage and wear during remainder of construction period. When remaining construction does not affect or endanger roofing system, inspect roofing system for deterioration and damage, describing its nature and extent in a written report, with copies to Architect and Owner.

B. Correct deficiencies in or remove roofing system that does not comply with requirements, repair substrates, and repair or reinstall roofing system to a condition free of damage and deterioration at time of Substantial Completion and according to warranty requirements.

C. Clean overspray and spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

3.13 ROOFING INSTALLER'S WARRANTY

A. WHEREAS _____ of _____, herein called the "Roofing Installer," has performed roofing and associated work ("work") on the following project:

1. Owner: <Insert name of Owner>.
2. Owner Address: <Insert address>.
3. Building Name/Type: <Insert information>.
4. Building Address: <Insert address>.
5. Area of Work: <Insert information>.
6. Acceptance Date: _____.
7. Warranty Period: <Insert time>.
8. Expiration Date: _____.

B. AND WHEREAS Roofing Installer has contracted (either directly with Owner or indirectly as a subcontractor) to warrant said work against leaks and faulty or defective materials and workmanship for designated Warranty Period,

C. NOW THEREFORE Roofing Installer hereby warrants, subject to terms and conditions herein set forth, that during Warranty Period Roofing Installer will, at Roofing Installer's own cost and expense, make or cause to be made such repairs to or replacements of said work as are necessary to correct faulty and defective work and as are necessary to maintain said work in a watertight condition.

D. This Warranty is made subject to the following terms and conditions:

1. Specifically excluded from this Warranty are damages to work and other parts of the building, and to building contents, caused by:

a. lightning;
b. peak gust wind speed exceeding 105 mph (m/sec)>;
c. fire;
d. failure of roofing system substrate, including cracking, settlement, excessive deflection, deterioration, and decomposition;

e. faulty construction of parapet walls, copings, chimneys, skylights, vents, equipment supports, and other edge conditions and penetrations of the work;
f. vapor condensation on bottom of roofing; and
g. activity on roofing by others, including construction contractors, maintenance personnel, other persons, and animals, whether authorized or unauthorized by Owner.

2. When work has been damaged by any of foregoing causes, Warranty shall be null and void until such damage has been repaired by Roofing Installer and until cost and expense thereof have been paid by Owner or by another responsible party so designated.
3. Roofing Installer is responsible for damage to work covered by this Warranty but is not liable for consequential damages to building or building contents resulting from leaks or faults or defects of work.
4. During Warranty Period, if Owner allows alteration of work by anyone other than Roofing Installer, including cutting, patching, and maintenance in connection with penetrations, attachment of other work, and positioning of anything on roof, this Warranty shall become null and void on date of said alterations, but only to the extent said alterations affect work covered by this Warranty. If Owner engages Roofing Installer to perform said alterations, Warranty shall not become null and void unless Roofing Installer, before starting said work, shall have notified Owner in writing, showing reasonable cause for claim, that said alterations would likely damage or deteriorate work, thereby reasonably justifying a limitation or termination of this Warranty.
5. During Warranty Period, if original use of roof is changed and it becomes used for, but was not originally specified for, a promenade, work deck, spray-cooled surface, flooded basin, or other use or service more severe than originally specified, this Warranty shall become null and void on date of said change, but only to the extent said change affects work covered by this Warranty.
6. Owner shall promptly notify Roofing Installer of observed, known, or suspected leaks, defects, or deterioration and shall afford reasonable opportunity for Roofing Installer to inspect work and to examine evidence of such leaks, defects, or deterioration.
7. This Warranty is recognized to be the only warranty of Roofing Installer on said work and shall not operate to restrict or cut off Owner from other remedies and resources lawfully available to Owner in cases of roofing failure. Specifically, this Warranty shall not operate to relieve Roofing Installer of responsibility for performance of original work according to requirements of the Contract Documents, regardless of whether Contract was a contract directly with Owner or a subcontract with Owner's General Contractor.

E. IN WITNESS THEREOF, this instrument has been duly executed this _____ day of _____, _____.

1. Authorized Signature: _____.
2. Name: _____.
3. Title: _____.

END OF SECTION 075423

SECTION 076200 - SHEET METAL FLASHING AND TRIM

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Sheet metal materials.
2. Underlayment.
3. Miscellaneous materials.

1.2 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: For sheet metal flashing and trim.

1. Plans, elevations, sections, and attachment details.
2. Identification of material, thickness, weight, and finish for each item and location in Project.
3. Details for forming, including profiles, shapes, seams, and dimensions.
4. Details for joining, supporting, and securing, including layout and spacing of fasteners, cleats, clips, and other attachments. Include pattern of seams.
5. Details of termination points and assemblies.
6. Details of roof-penetration flashing.
7. Details of special conditions.
8. Details of connections to adjoining work.
9. Formed flashing and trim at scale of not less than 1-1/2 inches per 12 inches (1:10).

C. Samples: For each exposed product and for each color and texture specified, 12 inches (300 mm) long by actual width.

1.3 INFORMATIONAL SUBMITTALS

A. Certificates: For each type of coping and roof edge flashing that is ANSI/SPRI/FM 4435/ES-1 tested and FM Approvals approved.

B. Product test reports.

C. Research reports.

D. Sample warranties.

1.4 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Entity that employs a supervisor who is an NRCA ProCertified Roofing Foreman or installers who are NRCA ProCertified Architectural Metal Flashings and Accessories Installers.

1.6 WARRANTY

A. Special Warranty on Finishes: Manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within specified warranty period.

1. Exposed Panel Finish: Deterioration includes, but is not limited to, the following:

a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
b. Chalking more than a No. 8 rating when tested in accordance with ASTM D4214.
c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

2. Finish Warranty Period: 10 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Sheet metal flashing and trim assemblies, including cleats, anchors, and fasteners, are to withstand wind loads, structural movement, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Completed sheet metal flashing and trim are not to rattle, leak, or loosen, and are to remain watertight.

B. Sheet Metal Standard for Flashing and Trim: Comply with NRCA's "The NRCA Roofing Manual: Architectural Metal Flashing, Condensation and Air Leakage Control, and Reroofing" and SMACNA's "Architectural Sheet Metal Manual" requirements for dimensions and profiles shown unless more stringent requirements are indicated.

C. Sheet Metal Standard for Copper: Comply with CDA's "Copper in Architecture Design Handbook." Conform to dimensions and profiles shown unless more stringent requirements are indicated.

D. SPRI Wind Design Standard: Manufacture and install roof edge flashings and copings tested in accordance with ANSI/SPRI/FM 4435/ES-1.

E. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F (67 deg C), ambient; 180 deg F (100 deg C), material surfaces.

## 2.2 SHEET METAL MATERIALS

A. Protect mechanical and other finishes on exposed surfaces from damage by applying strippable, temporary protective film before shipping.

B. Metallic-Coated Steel Sheet: Zinc-coated (galvanized) steel sheet complying with minimum ASTM A653/A653M, G90 (Z275) coating designation, or aluminum-zinc alloy-coated steel sheet complying with minimum ASTM A792/A792M, Class AZ50 (Class AZM150) coating designation; structural quality. Prepainted by the coil-coating process to comply with ASTM A755/A755M.

1. Nominal Thickness: 0.040 inch (1.02 mm).
2. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil (0.013 mm).

C. Pre-fabricated Aluminum Sheet: Coil-coated sheet, ASTM B209/B209M, alloy as standard with manufacturer, with temper as required to suit forming operations and structural performance required.

1. Thickness: 0.040 inch (1.02 mm).
2. Surface: Smooth, flat Embossed.
3. Exposed Coil-Coated Finish:

4. Color: As indicated by manufacturer's designations
5. Concealed Finish: Pretreat with manufacturer's standard white or light-colored acrylic or polyester backer finish, consisting of prime coat and wash coat with minimum total dry film thickness of 0.5 mil (0.013 mm).
6. Factory Prime Coating: Where painting after installation is required, pretreat metal with white or light-colored, factory-applied, baked-on epoxy primer coat; minimum dry film thickness of 0.2 mil (0.005 mm).
   a. and polish surfaces to produce uniform finish, free of cross scratches.

## 2.3 UNDERLAYMENT

A. Self-Adhering, High-Temperature Sheet Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 60 mils (0.76 mm) thick, specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D1970/D1970M.
2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (minus 29 deg C) or lower; ASTM D1970/D1970M.

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

   a. ATAS International, Inc.
   b. Carlisle WIP Products; a brand of Carlisle Construction Materials.
   c. Henry, a Carlisle Company (formerly Henry Company and Carlisle Coatings & Waterproofing Inc. brands).
   d. Owens Corning.
   e. Polyglass U.S.A., Inc.

B. Slip Sheet: Rosin-sized building paper, 3 lb/100 sq. ft. (0.16 kg/sq. m) minimum, of type required for application.

## 2.4 MISCELLANEOUS MATERIALS

A. Provide materials and types of fasteners, solder, protective coatings, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation and as recommended by manufacturer of primary sheet metal or manufactured item unless otherwise indicated.

B. Fasteners: Wood screws, annular threaded nails, self-tapping screws, self-locking rivets and bolts, and other suitable fasteners designed to withstand design loads and recommended by manufacturer of primary sheet metal or manufactured item.

   1. General: Blind fasteners or self-drilling screws, gasketed, with hex-washer head.

      a. Exposed Fasteners: Heads matching color of sheet metal using plastic caps or factory-applied coating. Provide metal-backed EPDM or PVC sealing washers under heads of exposed fasteners bearing on weather side of metal.
      b. Blind Fasteners: High-strength aluminum or stainless steel rivets suitable for metal being fastened.
      c. Spikes and Ferrules: Same material as gutter; with spike with ferrule matching internal gutter width.

   2. Fasteners for Zinc-Coated (Galvanized) or Aluminum-Zinc Alloy-Coated Steel Sheet: Series 300 stainless steel or hot-dip galvanized steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.
   3. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.

C. Solder:

   1. For Zinc-Coated (Galvanized) Steel: ASTM B32, Grade Sn50, 50 percent tin and 50 percent lead or Grade Sn60, 60 percent tin and 40 percent lead with maximum lead content of 0.2 percent.

D. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealant tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape 1/2 inch (13 mm) wide and 1/8 inch (3 mm) thick.

E. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polymer sealant; of type, grade, class, and use classifications required to seal joints in sheet metal flashing and trim and remain watertight.

F. Epoxy Seam Sealer: Two-part, noncorrosive, aluminum seam-cementing compound, recommended by aluminum manufacturer for exterior nonmoving joints, including riveted joints.

G. Reglets: Units of type, material, and profile required, formed to provide secure interlocking of separate reglet and counterflashing pieces, and compatible with flashing indicated with factory-mitered and -welded corners and junctions and with interlocking counterflashing on exterior face, of same metal as reglet.

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

   a. Heckmann Building Products, Inc.
   b. Hohmann & Barnard, Inc.
   c. Keystone Flashing Company, Inc.
   d. OMG Roofing Products; a Division of OMG, Inc.

2. Material: Galvanized steel, 0.022 inch (0.56 mm) thick
3. Masonry Type: Provide with offset top flange for embedment in masonry mortar joint.
4. Accessories:

   a. Flexible-Flashing Retainer: Provide resilient plastic or rubber accessory to secure flexible flashing in reglet where clearance does not permit use of standard metal counterflashing or where Drawings show reglet without metal counterflashing.
   b. Counterflashing Wind-Restraint Clips: Provide clips to be installed before counterflashing to prevent wind uplift of counterflashing's lower edge.

5. Finish: With manufacturer's standard color coating .

## 2.5 FABRICATION, GENERAL

A. Custom fabricate sheet metal flashing and trim to comply with details indicated and recommendations in cited sheet metal standard that apply to design, dimensions, geometry, metal thickness, and other characteristics of item required.

1. Fabricate sheet metal flashing and trim in shop to greatest extent possible.
2. Fabricate sheet metal flashing and trim in thickness or weight needed to comply with performance requirements, but not less than that specified for each application and metal.
3. Verify shapes and dimensions of surfaces to be covered and obtain field measurements for accurate fit before shop fabrication.
4. Form sheet metal flashing and trim to fit substrates without excessive oil-canning, buckling, and tool marks; true to line, levels, and slopes; and with exposed edges folded back to form hems.
5. Conceal fasteners and expansion provisions where possible. Do not use exposed fasteners on faces exposed to view.

B. Fabrication Tolerances:

1. Fabricate sheet metal flashing and trim that is capable of installation to a tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

C. Sealant Joints: Where movable, non-expansion-type joints are required, form metal in accordance with cited sheet metal standard to provide for proper installation of elastomeric sealant.

D. Fabricate cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal.

E. Seams:

1. Fabricate nonmoving seams with flat-lock seams. Tin edges to be seamed, form seams, and solder.
2. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints where necessary for strength.]

## 2.6 WALL SHEET METAL FABRICATIONS

A. Through-Wall Flashing: Fabricate continuous flashings in minimum 96-inch- (2400-mm-) long, but not exceeding 12 ft. (3.6 m) long, sections, under copings, and at shelf angles. Fabricate discontinuous lintel, sill, and similar flashings to extend 6 inches (150 mm) beyond each side of wall openings; and form with 2-inch- (50-mm-) high, end dams. Fabricate from the following materials:

1. Stainless Steel: 0.0156 inch (0.396 mm) thick.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, substrates, and other conditions affecting performance of the Work.

1. Verify compliance with requirements for installation tolerances of substrates.
2. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
3. Verify that air- or water-resistant barriers have been installed over substrate to prevent air infiltration or water penetration.

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

## 3.2 INSTALLATION OF UNDERLAYMENT

A. Self-Adhering, High-Temperature Sheet Underlayment:

1. Install self-adhering, high-temperature sheet underlayment; wrinkle free.
2. Prime substrate if recommended by underlayment manufacturer.
3. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures.
4. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses.
5. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps and edges with roller.
6. Roll laps and edges with roller.
7. Cover underlayment within 14 days.
8. Lapp joints not less than 4 inches (100 mm).

## 3.3 INSTALLATION OF SHEET METAL FLASHING AND TRIM, GENERAL

A. Install sheet metal flashing and trim to comply with details indicated and recommendations of cited sheet metal standard that apply to installation characteristics required unless otherwise indicated on Drawings.

1. Install fasteners, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.
2. Install sheet metal flashing and trim true to line, levels, and slopes. Provide uniform, neat seams with minimum exposure of welds and sealant.
3. Anchor sheet metal flashing and trim and other components of the Work securely in place, with provisions for thermal and structural movement.
4. Install sheet metal flashing and trim to fit substrates and to result in watertight performance.
5. Install continuous cleats with fasteners spaced not more than 12 inches (300 mm) o.c.
6. Space individual cleats not more than 12 inches (300 mm) apart. Attach each cleat with at least two fasteners. Bend tabs over fasteners.
7. Install exposed sheet metal flashing and trim with limited oil-canning, and free of buckling and tool marks.
8. Do not field cut sheet metal flashing and trim by torch.
9. Do not use graphite pencils to mark metal surfaces.

B. Metal Protection: Where dissimilar metals contact each other, or where metal contacts pressure-treated wood or other corrosive substrates, protect against galvanic action or corrosion by painting contact surfaces with bituminous coating or by other permanent separation as recommended by sheet metal manufacturer or cited sheet metal standard.

1. Coat concealed side of uncoated-aluminum and stainless steel] sheet metal flashing and trim with bituminous coating where flashing and trim contact wood, ferrous metal, or cementitious construction.
2. Underlayment: Where installing sheet metal flashing and trim directly on cementitious or wood substrates, install underlayment and cover with slip sheet.

C. Fasteners: Use fastener sizes that penetrate wood blocking or sheathing not less than 1-1/4 inches (32 mm) for nails not less than recommended by fastener manufacturer to achieve maximum pull-out resistance.

D. Conceal fasteners and expansion provisions where possible in exposed work and locate to minimize possibility of leakage. Cover and seal fasteners and anchors as required for a tight installation.

E. Seal joints as required for watertight construction.

1. Use sealant-filled joints unless otherwise indicated.

a. Embed hooked flanges of joint members not less than 1 inch (25 mm) into sealant.
b. Form joints to completely conceal sealant.
c. When ambient temperature at time of installation is between 40 and 70 deg F (4 and 21 deg C), set joint members for 50 percent movement each way.
d. Adjust setting proportionately for installation at higher ambient temperatures.

1) Do not install sealant-type joints at temperatures below 40 deg F (4 deg C).

2. Prepare joints and apply sealants to comply with requirements in Section 079200 "Joint Sealants."

F. Soldered Joints: Clean surfaces to be soldered, removing oils and foreign matter.

1. Pretin edges of sheets with solder to width of 1-1/2 inches (38 mm); however, reduce pretinning where pretinned surface would show in completed Work.
2. Do not solder metallic-coated steel and aluminum sheet.
3. Do not use torches for soldering.
4. Heat surfaces to receive solder, and flow solder into joint.

a. Fill joint completely.
b. Completely remove flux and spatter from exposed surfaces.

5. Stainless Steel Soldering:

a. Tin edges of uncoated sheets, using solder for stainless steel and acid flux.
b. Promptly remove acid-flux residue from metal after tinning and soldering.
c. Comply with solder manufacturer's recommended methods for cleaning and neutralization.

G. Rivets: Rivet joints in uncoated aluminum where necessary for strength.

## 3.4 INSTALLATION OF SLOPED ROOF SHEET METAL FABRICATIONS

A. Install sheet metal flashing and trim to comply with performance requirements, sheet metal manufacturer's written installation instructions, and cited sheet metal standard.

1. Provide concealed fasteners where possible, and set units true to line, levels, and slopes.
2. Install work with laps, joints, and seams that are permanently watertight and weather resistant.

B. Pipe or Post Counterflashing: Install counterflashing umbrella with close-fitting collar with top edge flared for elastomeric sealant, extending minimum of 4 inches (100 mm) over base flashing. Install stainless steel draw band and tighten.

C. Counterflashing: Coordinate installation of counterflashing with installation of base flashing.

1. Insert counterflashing in reglets or receivers and fit tightly to base flashing.
2. Extend counterflashing 4 inches (100 mm) over base flashing.
3. Lap counterflashing joints minimum of 4 inches (100 mm).

D. Roof-Penetration Flashing: Coordinate installation of roof-penetration flashing with installation of roofing and other items penetrating roof. Seal with elastomeric sealant and clamp flashing to pipes that penetrate roof.

## 3.5 INSTALLATION OF WALL SHEET METAL FABRICATIONS

A. Install sheet metal wall flashing to intercept and exclude penetrating moisture in accordance with cited sheet metal standard unless otherwise indicated. Coordinate installation of wall flashing with installation of wall-opening components such as windows, doors, and louvers.

## 3.6 INSTALLATION TOLERANCES

A. Shim and align sheet metal flashing and trim within installed tolerance of 1/4 inch in 20 ft. (6 mm in 6 m) on slope and location lines indicated on Drawings and within 1/8-inch (3-mm) offset of adjoining faces and of alignment of matching profiles.

## 3.7 CLEANING

A. Clean exposed metal surfaces of substances that interfere with uniform oxidation and weathering.

B. Clean off excess sealants.

## 3.8 PROTECTION

A. Remove temporary protective coverings and strippable films as sheet metal flashing and trim are installed unless otherwise indicated in manufacturer's written installation instructions.

B. Replace sheet metal flashing and trim that have been damaged or that have deteriorated beyond successful repair by finish touchup or similar minor repair procedures, as determined by Architect.

END OF SECTION 076200

SECTION 077200 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes: Manufactured units for the following applications:

1. Roof curbs.
2. Equipment supports.
3. Heat and smoke vents.
4. Underlayment.
5. Miscellaneous materials.

1.2 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: For roof accessories.

1. Include plans, elevations, keyed details, and attachments to other work. Indicate dimensions, loadings, and special conditions. Distinguish between plant- and field-assembled work.

C. Delegated Design Submittals: For roof curbs and equipment supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Detail mounting, securing, and flashing of roof-mounted items to roof structure. Indicate coordinating requirements with roof membrane system.
2. Wind-Restraint Details: Detail fabrication and attachment of wind restraints. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Samples: For each type of roof accessory indicated with factory-applied color finishes.

1.3 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Roof plans, drawn to scale, and coordinating penetrations and roof-mounted items.

B. Qualification statements.

1.4 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. General Performance: Roof accessories to withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.

B. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design roof curbs and equipment supports to comply with wind performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

C. Wind-Restraint Performance: As indicated on Drawings.

2.2 ROOF CURBS

A. Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, and integrally formed deck-mounting flange at perimeter bottom.

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

1. AES Industries, Inc.
2. ATAS International, Inc.
3. Air Balance; MESTEK, Inc.
4. Lloyd Industries, Inc.
5. Roof Products and Systems (RPS); Duravent Group.
6. Roof Products, Inc.
7. Vent Products Co., Inc.

C. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

D. Supported Load Capacity: Coordinate load capacity with information on Shop Drawings of equipment to be supported.

E. Stainless Steel: 0.0781 inch (1.983 mm) thick sheet.

1. Finish: Manufacturer's standard.

F. Construction:

1. Curb Profile: Manufacturer's standard compatible with roofing system.
2. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
3. Fabricate curbs to minimum height of 12 inches (305 mm) above roofing surface unless otherwise indicated.

4. Top Surface: Level top of curb, with roof slope accommodated by sloping deck-mounting flange or by use of leveler frame.
5. Sloping Roofs: Where roof slope exceeds 1/4 inch per 12 inches (1:48), fabricate curb with perimeter curb height tapered to accommodate roof slope so that top surface of perimeter curb is level. Equip unit with water diverter or cricket on side that obstructs water flow.
6. Insulation: Factory insulated with 1-1/2-inch- (38-mm-) thick glass-fiber board insulation.
7. Liner: Same material as curb, of manufacturer's standard thickness and finish.
8. Nailer: Factory-installed wood nailer along top flange of curb, continuous around curb perimeter.
9. Wind-Restraint Straps and Base Flange Attachment: Provide wind-restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to comply with wind-uplift requirements.
10. Platform Cap: Where portion of roof curb is not covered by equipment, provide weathertight platform cap formed from 3/4-inch- (19-mm-) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
11. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.
12. Damper Tray: Provide damper tray or shelf with opening 3 inches (76 mm) less than interior curb dimensions indicated.

## 2.3 EQUIPMENT SUPPORTS

A. Internally reinforced perimeter metal equipment supports capable of supporting superimposed live and dead loads between structural supports, including equipment loads and other construction indicated on Drawings, spanning between structural supports; capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, integral metal cant, and integrally formed structure-mounting flange at bottom.

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

1. AES Industries, Inc.
2. Air Balance; MESTEK, Inc.
3. JL Industries; Activar Construction Products Group, Inc.
4. Lloyd Industries, Inc.
5. Vent Products Co., Inc.

C. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.

D. Supported Load Capacity: Coordinate load capacity with information on Shop Drawings of equipment to be supported.

E. Stainless Steel: 0.0781 inch (1.983 mm) thick sheet.

1. Finish: Manufacturer's standard.

F. Construction:

1. Curb Profile: Manufacturer's standard compatible with roofing system.

2. Insulation: Factory insulated with 1-1/2-inch- (38-mm-) thick glass-fiber board insulation.
3. Liner: Same material as equipment support, of manufacturer's standard thickness and finish.
4. Wind-Restraint Straps and Base Flange Attachment: Provide wind-restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb of size and spacing required to comply with wind-uplift requirements.
5. Platform Cap: Where portion of equipment support is not covered by equipment, provide weathertight platform cap formed from 3/4-inch- (19-mm-) thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
6. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as equipment support.
7. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
8. Fabricate equipment supports to minimum height of 2 inches (305 mm) above roofing surface unless otherwise indicated.
9. Sloping Roofs: Where roof slope exceeds 1/4 inch per 12 inches (1:48), fabricate each support with height to accommodate roof slope so that tops of supports are level with each other. Equip supports with water diverters or crickets on sides that obstruct water flow.

## 2.4 METAL MATERIALS

A. Stainless Steel Sheet and Shapes: ASTM A240/A240M or ASTM A666, Type 304.

B. Galvanized-Steel Tube: ASTM A500/A500M, round tube, hot-dip galvanized in accordance with ASTM A123/A123M.

## 2.5 UNDERLAYMENT

A. Self-Adhering, High-Temperature Sheet Underlayment: Provide self-adhering, cold-applied, sheet underlayment, a minimum of 30 mils (0.76 mm) thick, specifically designed to withstand high metal temperatures beneath metal roofing. Provide primer when recommended by underlayment manufacturer.

1. Thermal Stability: Stable after testing at 240 deg F (116 deg C); ASTM D1970/D1970M.
2. Low-Temperature Flexibility: Passes after testing at minus 20 deg F (minus 29 deg C) or lower; ASTM D1970/D1970M.

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

   a. ATAS International, Inc.
   b. Carlisle WIP Products; a brand of Carlisle Construction Materials.
   c. Henry, a Carlisle Company (formerly Henry Company and Carlisle Coatings & Waterproofing Inc. brands).
   d. Polyglass U.S.A., Inc.

## 2.6 MISCELLANEOUS MATERIALS

A. Provide materials and types of fasteners, protective coatings, sealants, and other miscellaneous items required by manufacturer for a complete installation.

B. Glass-Fiber Board Insulation: ASTM C726, nominal density of 3 lb/cu. ft. (48 kg/cu. m), thermal resistivity of 4.3 deg F x h x sq. ft./Btu x in. at 75 deg F (29.8 K x m/W at 24 deg C), thickness as indicated.

C. Fasteners: Roof accessory manufacturer's recommended fasteners, designed to comply with performance requirements, suitable for application and metals being fastened. Match finish of exposed fasteners with finish of material being fastened. Provide nonremovable fastener heads to exterior exposed fasteners. Furnish the following unless otherwise indicated:

1. Fasteners for Metallic-Coated Steel Sheet: Series 300 stainless steel or hot-dip zinc-coated steel in accordance with ASTM A153/A153M or ASTM F2329/F2329M.
2. Fasteners for Aluminum Sheet: Aluminum or Series 300 stainless steel.
3. Fasteners for Stainless Steel Sheet: Series 300 stainless steel.

D. Gaskets: Manufacturer's standard tubular or fingered design of neoprene, EPDM, PVC, or silicone or a flat design of foam rubber, sponge neoprene, or cork.

E. Elastomeric Sealant: ASTM C920, elastomeric polyurethane polymer sealant as recommended by roof accessory manufacturer for installation indicated; low modulus; of type, grade, class, and use classifications required to seal joints and remain watertight.

F. Butyl Sealant: ASTM C1311, single-component, solvent-release butyl rubber sealant; polyisobutylene plasticized; heavy bodied for expansion joints with limited movement.

G. Bituminous Coating: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

## 2.7 GENERAL FINISH REQUIREMENTS

A. Comply with NAAMM/NOMMA AMP 500, "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

B. Protect mechanical and painted finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Appearance of Finished Work: Noticeable variations in same piece are not acceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

# PART 3 - EXECUTION

## 3.1 INSTALLATION OF UNDERLAYMENT

A. Self-Adhering, High-Temperature Sheet Underlayment:

1. Install self-adhering, high-temperature sheet underlayment; wrinkle free.

2. Prime substrate if recommended by underlayment manufacturer.
3. Comply with temperature restrictions of underlayment manufacturer for installation; use primer for installing underlayment at low temperatures.
4. Apply in shingle fashion to shed water, with end laps of not less than 6 inches (150 mm) staggered 24 inches (600 mm) between courses.
5. Overlap side edges not less than 3-1/2 inches (90 mm). Roll laps and edges with roller.
6. Roll laps and edges with roller.
7. Cover underlayment within 14 days.

## 3.2 INSTALLATION, GENERAL

A. Install roof accessories in accordance with manufacturer's written instructions.

1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.

B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended in writing by manufacturer's written installation instructions.

1. Coat concealed side of uncoated aluminum and stainless steel roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
2. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof accessories for waterproof performance.

## 3.3 INSTALLATION OF ROOF ACCESSORIES

A. Roof Curb: Install each roof curb so top surface is level.

B. Equipment Support: Install equipment supports so top surfaces are level with each other.

C. Seal joints with elastomeric or butyl sealant as required by roof accessory manufacturer.

## 3.4 CLEANING AND PROTECTION

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing in accordance with ASTM A780/A780M.

B. Touch up factory-primed surfaces with compatible primer ready for field painting in accordance with Section 099113 "Exterior Painting."

C. On completion of installation, clean exposed surfaces in according with manufacturer's written instructions. Clean off excess sealants.

D. Remove temporary protective coverings and strippable films as roof accessories are installed. On completion of installation, clean finished surfaces, including removing unused fasteners, metal filings, pop rivet stems, and pieces of flashing. Maintain roof accessories in a clean condition during construction.

E. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures, as determined by Architect.

END OF SECTION 077200

# SECTION 078413 - PENETRATION FIRESTOPPING

## PART 1 - GENERAL

### 1.1 SUMMARY

A. Section Includes:

1. Penetration firestopping systems.
2. Penetrations in fire-resistance-rated walls.
3. Penetrations in horizontal assemblies.
4. Exposed penetration firestopping systems.

### 1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

### 1.3 ACTION SUBMITTALS

A. Product data.

### 1.4 INFORMATIONAL SUBMITTALS

A. Listed system designs.

### 1.5 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that penetration firestopping systems have been installed in compliance with requirements and manufacturer's written instructions.

### 1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Entity that has received UL's "Firestop Movement Certification," which demonstrates that manufacturer's firestopping products designated with M-Ratings are based on exposure to cyclic movement and UL 1479 fire test evaluation when tested in accordance with ASTM E3037.

## PART 2 - PRODUCTS

### 2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:

1. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
2. Test in accordance with testing standards referenced in "Penetration Firestopping Systems" Article. Provide rated systems complying with the following requirements:

    a. Penetration firestop systems installed with products bearing the classification marking of a qualified testing agency.

        1) UL in its online directory "Product iQ."
        2) Intertek Group in its "Directory of Building Products."
        3) FM Approvals in its "Approval Guide."

## 2.2 PENETRATION FIRESTOPPING SYSTEMS

A. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems are to be compatible with one another, with the substrates forming openings, and with penetrating items if any.

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

    a. 3M Building and Construction.
    b. Balco; a CSW Industrials Company.
    c. FireShield; Fire Rated Solutions LLC.
    d. International Fireproof Technology Inc.
    e. Tremco Incorporated.

B. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.

1. F-Rating: Not less than the fire-resistance rating of the wall penetrated.
2. Membrane Penetrations: Install recessed fixtures such that the required fire resistance will not be reduced.

C. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined in accordance with ASTM E814 or UL 1479.

1. F-Rating: At least one hour, but not less than the fire-resistance rating of the floor penetrated.
2. T-Rating: At least one hour, but not less than the fire-resistance rating of the floor. The following floor penetrations do not require a T-rating:

    a. Those within the cavity of a wall.
    b. Floor, tub, or shower drains within a concealed space.
    c. 4-inch (200-mm) or smaller metal conduit penetrating directly into metal-enclosed electrical switchgear.

D. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, when tested in accordance with ASTM E84 or UL 723.

E. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF PENETRATION FIRESTOPPING SYSTEMS

A. Examine substrates and conditions, with Installer present, for compliance with requirements for opening configurations, penetrating items, substrates, and other conditions affecting performance of the Work.

B. General: Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.

C. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.

1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.

D. Install fill materials by proven techniques to produce the following results:

1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

### 3.2 IDENTIFICATION

A. Wall Identification: Permanently label walls containing penetration firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches (76 mm) high and with minimum 0.375-inch (9.5-mm) strokes.

1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 ft. (4.57 m) from end of wall and at intervals not exceeding 30 ft. (9.14 m).

B. Penetration Identification: Identify each penetration firestopping system with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches (150 mm) of penetration firestopping system edge so labels are visible to anyone seeking to remove penetrating items or firestopping systems. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words "Warning - Penetration Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Designation of applicable testing and inspecting agency.
4. Date of installation.
5. Manufacturer's name.
6. Installer's name.

## 3.3 FIELD QUALITY CONTROL

A. Architect/Engineer will conduct on-site inspections and report installation in accordance with ASTM E2174.

B. Where deficiencies are found or penetration firestopping system is damaged or removed because of testing, repair or replace penetration firestopping system to comply with requirements.

C. Proceed with enclosing penetration firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

END OF SECTION 078413

SECTION 078443 - JOINT FIRESTOPPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Joints in or between fire-resistance-rated construction.
2. Joints in fire-rated smoke barriers.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product data.

B. Product Schedule: For each joint firestopping system. Include location, illustration of firestopping system, and design designation of qualified testing agency.

1. Engineering Judgments: Where Project conditions require modification to a qualified testing agency's illustration for a particular joint firestopping system condition, submit illustration, with modifications marked, approved by joint firestopping system manufacturer's fire-protection engineer as an EJ or equivalent fire-resistance-rated assembly developed in accordance with current IFC guidelines.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Listed System Designs: For each joint firestopping system, for tests performed by a qualified testing agency.

1.5 CLOSEOUT SUBMITTALS

A. Installer Certificates: From Installer indicating that joint firestopping systems have been installed in compliance with requirements and manufacturer's written installation instructions.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: A firm that has been approved by FM Approvals in accordance with FM Approvals 4991 or been evaluated by UL and found to comply with UL's "UL Solutions Qualified Firestop Contractor Program."

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics:

1. A qualified testing agency, acceptable to authorities having jurisdiction, will perform joint firestopping system tests.
2. Test in accordance with testing standards referenced in "Joint Firestopping Systems" Article. Provide rated systems complying with the following requirements:

    a. Joint firestop systems installed with products bearing the classification marking of a qualified product certification agency in accordance with listed system designs published by a qualified testing agency.

        1) UL in its online directory "Product iQ."
        2) Intertek Group in its "Directory of Building Products."

B. Rain/Water Resistance: For perimeter fire-barrier system applications, where inclement weather or greater-than-transient water exposure is expected, use products that dry rapidly and cure in the presence of atmospheric moisture sufficient to pass ASTM D6904 early rain-resistance test (24-hour exposure).

## 2.2 JOINT FIRESTOPPING SYSTEM TYPES

A. General: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of assemblies in or between which joint firestopping systems are installed. Joint firestopping systems must accommodate building movements without impairing their ability to resist the passage of fire and hot gases.

1. Joint firestopping systems that are compatible with one another, with the substrates forming openings, and with penetrating items, if any.
2. Provide products that, upon curing, do not re-emulsify, dissolve, leach, break down, or otherwise deteriorate over time from exposure to atmospheric moisture, sweating pipes, ponding water or other forms of moisture.
3. Provide firestop products that do not contain ethylene glycol.

B. Joints in or between Fire-Resistance-Rated Construction: Provide joint firestopping systems with ratings determined in accordance with ASTM E1966 or UL 2079, with published L-Ratings for ambient and elevated temperatures as evidence of the ability of the fire-resistive joint system to restrict the movement of smoke.

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

    a. 3M Building and Construction.
    b. Balco; a CSW Industrials Company.
    c. CEMCO; California Expanded Metal Products Co.
    d. ClarkDietrich.
    e. Hilti, Inc.
    f. International Fireproof Technology Inc.
    g. Owens Corning.
    h. ROCKWOOL.
    i. Tremco Incorporated.

2. Fire-Resistance Rating: Equal to or exceeding the fire-resistance rating of the wall, floor, or roof in or between which it is installed.

C. Joints in Smoke Barriers: Provide joint firestopping systems with ratings determined in accordance with UL 2079 based on testing at a positive pressure differential of 0.30 inch wg (74.7 Pa).

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

    a. 3M Building and Construction.
    b. Balco; a CSW Industrials Company.
    c. CEMCO; California Expanded Metal Products Co.
    d. Hilti, Inc.
    e. Owens Corning.
    f. Tremco Incorporated.
    g. Willseal LLC, part of Tremco CPG.

2. L-Rating: Not exceeding 5.0 cfm/ft. (0.00775 cu. m/s x m) of joint at both ambient and elevated temperatures.

D. Exposed Joint Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined in accordance with ASTM E84.

## 2.3 ACCESSORIES

A. Provide components of joint firestopping systems, including primers and forming materials, that are needed to install elastomeric fill materials and to maintain ratings required. Use only components specified by joint firestopping system manufacturer and approved by the qualified testing agency for conditions indicated.

## PART 3 - EXECUTION

### 3.1 PREPARATION

A. Surface Cleaning: Before installing joint firestopping systems, clean joints in accordance with fire-resistive joint system manufacturer's written installation instructions and the following requirements:

1. Remove foreign materials from substrate surfaces that could interfere with adhesion of elastomeric fill materials or compromise fire-resistive rating.
2. Clean joint substrates to produce clean, sound surfaces capable of developing optimum bond with elastomeric fill materials. Remove loose particles remaining from cleaning operation.
3. Remove laitance and form-release agents from concrete.

B. Prime substrates in accordance with joint firestopping system manufacturer's written installation instructions, using that manufacturer's recommended products and methods. Confine primers to areas of bond; do not allow spillage and migration onto exposed surfaces.

C. Apply a suitable bond breaker to prevent three-sided adhesion in applications where condition occurs.

### 3.2 INSTALLATION

A. General: Install joint firestopping systems in accordance with manufacturer's written installation instructions and published drawings for products and applications indicated.

B. Install forming materials and other accessories of types required to support elastomeric fill materials during their application and in position needed to produce cross-sectional shapes and depths required to achieve fire ratings indicated.

1. After installing elastomeric fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not indicated as permanent components of fire-resistive joint system.

C. Install elastomeric fill materials for joint firestopping systems by proven techniques to produce the following results:

1. Apply elastomeric fill in voids and cavities formed by joints and forming materials as required to achieve fire-resistance ratings indicated.
2. Apply elastomeric fill materials so they contact and adhere to substrates formed by joints.
3. For elastomeric fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.

### 3.3 IDENTIFICATION

A. Wall Identification: Permanently label walls containing firestopping systems with the words "FIRE AND/OR SMOKE BARRIER - PROTECT ALL OPENINGS," using lettering not less than 3 inches (76 mm) high and with minimum 0.375-inch (9.5-mm) strokes.

1. Locate in accessible concealed floor, floor-ceiling, or attic space at 15 ft. (4.57 m) from end of wall and at intervals not exceeding 30 ft. (9.14 m).

B. Joint Identification: Identify joint firestopping systems with legible metal or plastic labels. Attach labels permanently to surfaces adjacent to and within 6 inches (150 mm) of joint edge, so labels are visible to anyone seeking to remove joint firestopping system. Use mechanical fasteners or self-adhering-type labels with adhesives capable of permanently bonding labels to surfaces on which labels are placed. Include the following information on labels:

1. The words "Warning - Joint Firestopping - Do Not Disturb. Notify Building Management of Any Damage."
2. Contractor's name, address, and phone number.
3. Designation of applicable testing agency.
4. Date of installation.
5. Manufacturer's name.
6. Installer's name.

## 3.4 FIELD QUALITY CONTROL

A. Architect/Engineer will perform inspections to verify installation is in accordance with ASTM E2393.

B. Where deficiencies are found or joint firestopping systems are damaged or removed due to testing, repair or replace joint firestopping systems so they comply with requirements.

C. Proceed with enclosing joint firestopping systems with other construction only after inspection reports are issued and installations comply with requirements.

## 3.5 CLEANING AND PROTECTION

A. Clean off excess elastomeric fill materials adjacent to joints as the Work progresses by methods and with cleaning materials that are approved in writing by joint firestopping system manufacturers and that do not damage materials in which joints occur.

B. Provide final protection and maintain conditions during and after installation that ensure joint firestopping systems are without damage or deterioration at time of Substantial Completion. If damage or deterioration occurs despite such protection, cut out and remove damaged or deteriorated joint firestopping systems immediately and install new materials to produce joint firestopping systems complying with specified requirements.

END OF SECTION 078443

SECTION 079200 - JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Silicone joint sealants.
2. Nonstaining silicone joint sealants.
3. Mildew-resistant joint sealants.
4. Latex joint sealants.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site

1.3 ACTION SUBMITTALS

A. Product data.

B. Samples: Manufacturer's standard color charts consisting of strips of cured sealants showing the full range of colors available for each product exposed to view.

C. Joint-sealant schedule.

1.4 INFORMATIONAL SUBMITTALS

A. Field Quality-Control Reports: For field-adhesion-test reports, for each sealant application tested.

B. Sample warranties.

1.5 CLOSEOUT SUBMITTALS

A. Warranty Documentation:

1. Manufacturers' special warranties.
2. Installer's special warranties.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Authorized representative who is trained and approved by manufacturer.

B. Testing Agency Qualifications: Qualified in accordance with ASTM C1021 to conduct the testing indicated.

## 1.7 WARRANTY

A. Special Installer's Warranty: Installer agrees to repair or replace joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

B. Special Manufacturer's Warranty: Manufacturer agrees to furnish joint sealants to repair or replace those joint sealants that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: Five years from date of Substantial Completion.

C. Special warranties specified in this article exclude deterioration or failure of joint sealants from the following:

1. Movement of the structure caused by stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression.
2. Disintegration of joint substrates from causes exceeding design specifications.
3. Mechanical damage caused by individuals, tools, or other outside agents.
4. Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

# PART 2 - PRODUCTS

## 2.1 JOINT SEALANTS, GENERAL

A. Compatibility: Provide joint sealants, backings, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer, based on testing and field experience.

B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

## 2.2 SILICONE JOINT SEALANTS

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

a. Adfast.
b. Pecora Corporation.
c. Sika Corporation - Building Components.
d. Tremco Incorporated.

B. Silicone, S, NS, 100/50, NT: Single-component, nonsag, plus 100 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 100/50, Use NT.

C. Silicone, S, NS, 50, NT: Single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Use NT.

D. Silicone, S, NS, 35, NT: Single-component, nonsag, plus 35 percent and minus 35 percent movement capability. nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 35, Use NT.

E. Silicone, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

F. Silicone, Acid Curing, S, NS, 25, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

G. Silicone, S, NS, 100/50, T, NT: Single-component, nonsag, plus 100 percent and minus 50 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 100/50, Uses T and NT.

H. Silicone, S, NS, 50, T, NT: Single-component, nonsag, plus 50 percent and minus 50 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Uses T and NT.

I. Silicone, S, NS, 25, T, NT: Single-component, nonsag, plus 25 percent and minus 25 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25,

J. Silicone, S, P, 100/50, T, NT: Single-component, pourable, plus 100 percent and minus 50 percent movement capability traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade P, Class 100/50, Uses T and NT.

K. Silicone, M, P, 100/50, T, NT: Multicomponent, pourable, plus 100 percent and minus 50 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type M, Grade P, Class 100/50, Uses T and NT.

## 2.3 NONSTAINING SILICONE JOINT SEALANTS

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

a. Adfast.
b. Pecora Corporation.
c. Sika Corporation - Building Components.
d. Tremco Incorporated.

B. Nonstaining Joint Sealants: No staining of substrates when tested in accordance with ASTM C1248.

C. Silicone, Nonstaining, S, NS, 100/50, NT: Nonstaining, single-component, nonsag, plus 100 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 100/50, Use NT.

D. Silicone, Nonstaining, S, NS, 50, NT: Nonstaining, single-component, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 50, Use NT.

E. Silicone, Nonstaining, S, NS, 100/50, T, NT: Nonstaining, single-component, nonsag, plus 100 percent and minus 50 percent movement capability, traffic- and nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 100/50, Uses T and NT.

F. Silicone, Nonstaining, M, NS, 50, NT: Nonstaining, multicomponent, nonsag, plus 50 percent and minus 50 percent movement capability, nontraffic-use, neutral-curing silicone joint sealant; ASTM C920, Type M, Grade NS, Class 50, Use NT.

## 2.4 MILDEW-RESISTANT JOINT SEALANTS

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

   a. Adfast.
   b. Pecora Corporation.
   c. Sika Corporation - Building Components.
   d. Tremco Incorporated.

B. Mildew-Resistant Joint Sealants: Formulated for prolonged exposure to humidity with fungicide to prevent mold and mildew growth.

C. Silicone, Mildew Resistant, Acid Curing, S, NS, 25, NT: Mildew-resistant, single-component, nonsag, plus 25 percent and minus 25 percent movement capability, nontraffic-use, acid-curing silicone joint sealant; ASTM C920, Type S, Grade NS, Class 25, Use NT.

## 2.5 JOINT-SEALANT BACKING

A. Sealant Backing Material, General: Nonstaining; compatible with joint substrates, sealants, primers, and other joint fillers; and approved for applications indicated by sealant manufacturer based on field experience and laboratory testing.

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

      a. Adfast.
      b. Alcot Plastics Ltd.
      c. Construction Foam Products; a division of Nomaco, Inc.

B. Cylindrical Sealant Backings: ASTM C1330, Type C (closed-cell material with a surface skin) as approved in writing by joint-sealant manufacturer for joint application indicated], and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint-filler materials or joint surfaces at back of joint. Provide self-adhesive tape where applicable.

## 2.6 MISCELLANEOUS MATERIALS

A. Primer: Material recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Chemical cleaners acceptable to manufacturers of sealants and sealant backing materials, free of oily residues or other substances capable of staining or harming joint substrates and adjacent nonporous surfaces in any way, and formulated to promote optimum adhesion of sealants to joint substrates.

C. Masking Tape: Nonstaining, nonabsorbent material compatible with joint sealants and surfaces adjacent to joints.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
2. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air. Porous joint substrates include the following:

    a. Concrete.
    b. Masonry.
    c. Unglazed surfaces of ceramic tile.
    d. Exterior insulation and finish systems.

3. Remove laitance and form-release agents from concrete.

4. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants. Nonporous joint substrates include the following:

    a. Metal.
    b. Glass.
    c. Porcelain enamel.
    d. Glazed surfaces of ceramic tile.

B. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.

## 3.2 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.

B. Sealant Installation Standard: Comply with recommendations in ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install sealant backings of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

    1. Do not leave gaps between ends of sealant backings.
    2. Do not stretch, twist, puncture, or tear sealant backings.
    3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.

D. Install sealants using proven techniques that comply with the following and at the same time backings are installed:

    1. Place sealants so they directly contact and fully wet joint substrates.
    2. Completely fill recesses in each joint configuration.
    3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants in accordance with requirements specified in subparagraphs below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

    1. Remove excess sealant from surfaces adjacent to joints.

2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
3. Provide concave joint profile in accordance with Figure 8A in ASTM C1193 unless otherwise indicated.
4. Provide flush joint profile at in accordance with Figure 8B in ASTM C1193.
5. Provide recessed joint configuration of recess depth and at in accordance with Figure 8C in ASTM C1193.

    a. Use masking tape to protect surfaces adjacent to recessed tooled joints.

F. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

G. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

## 3.3 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage manufacturer’s inspection personnel to perform tests and inspections.

B. Tests and Inspections:

1. Field-Adhesion Testing: Field test joint-sealant adhesion to joint substrates as follows:

    a. Test Method: Test joint sealants in accordance with Method A, Tail Procedure, in ASTM C1521.

        1) For joints with dissimilar substrates, verify adhesion to each substrate separately; extend cut along one side, verifying adhesion to opposite side. Repeat procedure for opposite side.

    b. Inspect tested joints and report on the following:

        1) Whether sealants filled joint cavities and are free of voids.
        2) Whether sealant dimensions and configurations comply with specified requirements.
        3) Whether sealants in joints connected to pulled-out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each kind of product and joint substrate. Compare these results to determine if adhesion complies with sealant manufacturer's field-adhesion hand-pull test criteria.

    c. Record test results in a field-adhesion-test log. Include dates when sealants were installed, names of persons who installed sealants, test dates, test locations,

whether joints were primed, adhesion results and percent elongations, sealant material, sealant configuration, and sealant dimensions.

d. Repair sealants pulled from test area by applying new sealants following same procedures used originally to seal joints. Ensure that original sealant surfaces are clean and that new sealant contacts original sealant.

2. Evaluation of Field-Adhesion-Test Results: Sealants not evidencing adhesive failure from testing or noncompliance with other indicated requirements will be considered satisfactory. Remove sealants that fail to adhere to joint substrates during testing or to comply with other requirements. Retest failed applications until test results prove sealants comply with indicated requirements.

C. Prepare test and inspection reports.

END OF SECTION 079200

SECTION 081113 - HOLLOW METAL DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior standard steel doors and frames.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: Include the following:

1. Elevations of each door type.
2. Details of doors, including vertical- and horizontal-edge details and metal thicknesses.
3. Frame details for each frame type, including dimensioned profiles and metal thicknesses.

C. Product Schedule: For hollow-metal doors and frames, prepared by or under the supervision of supplier, using same reference numbers for details and openings as those on Drawings. Coordinate with final door hardware schedule.

1.3 INFORMATIONAL SUBMITTALS

A. Product test reports.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.5 QUALITY ASSURANCE

A. Fire-Rated Door Inspector Qualifications: Inspector for field quality-control inspections of fire-rated door assemblies is to meet the qualifications set forth in NFPA 80, Section 5.2.3.1 and the following:

B. Egress Door Inspector Qualifications: Inspector for field quality-control inspections of egress door assemblies is to meet the qualifications set forth in NFPA 101, Section 7.2.1.15.4 and the following:

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Apex Industries, Inc.
2. Ceco Door; AADG, Inc.; ASSA ABLOY.
3. DKS Steel Door & Frame Systems, Inc.
4. LaForce, LLC.
5. MPI Group, LLC (The).
6. National Custom Hollow Metal Doors & Frames.

2.2 PERFORMANCE REQUIREMENTS

A. Fire-Rated Door Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated on Drawings, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.

1. Smoke- and Draft-Control Door Assemblies: Listed and labeled for smoke and draft control by a qualified testing agency acceptable to authorities having jurisdiction, based on testing in accordance with UL 1784 and installed in compliance with NFPA 105.

B. Fire-Rated, Borrowed-Lite Assemblies: Assemblies complying with NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction, for fire-protection ratings indicated, based on testing in accordance with NFPA 257 or UL 9.

2.3 INTERIOR STANDARD STEEL DOORS AND FRAMES

A. Construct hollow-metal doors and frames to comply with standards indicated for materials, fabrication, hardware locations, hardware reinforcement, tolerances, and clearances, and as specified.

B. Frames:
1. Materials:
a. Standard Duty: Metallic coated steel sheet, minimum thickness of 0.042 inch (1.3 mm).
b. Heavy Duty: Metallic coated steel sheet, minimum thickness of 0.053 inch (1.3 mm).
c. Extra-Heavy Duty: Metallic coated steel sheet, minimum thickness of 0.053 inch (1.7 mm).
2. Construction: Full profile welded.

C. Standard-Duty Doors and Frames: ANSI/SDI A250.8, Level 1; ANSI/SDI A250.4, Level C. At locations indicated in the Door and Frame Schedule on Drawings.

1. Doors:

a. Type: As indicated in the Door and Frame Schedule on Drawings.
b. Thickness: 1-3/4 inches (44.5 mm).
c. Face: Metallic-coated steel sheet, minimum thickness of 0.032 inch (0.8 mm).
d. Edge Construction: Model 1, Full Flush.
e. Core: Manufacturer's standard.
f. Fire-Rated Core: Manufacturer's standard vertical steel stiffener core for fire-rated and temperature-rise-rated doors.

D. Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 2; ANSI/SDI A250.4, Level B. At locations indicated in the Door and Frame Schedule on Drawings.

1. Doors:

a. Type: As indicated in the Door and Frame Schedule on Drawings.
b. Thickness: 1-3/4 inches (44.5 mm).
c. Face: Metallic-coated steel sheet, minimum thickness of 0.042 inch (1.0 mm).
d. Edge Construction: Model 1, Full Flush.
e. Core: Manufacturer's standard Vertical steel stiffener.
f. Fire-Rated Core: Manufacturer's standard vertical steel stiffener core for fire-rated and temperature-rise-rated doors.

E. Extra-Heavy-Duty Doors and Frames: ANSI/SDI A250.8, Level 3; ANSI/SDI A250.4, Level A. At locations indicated in the Door and Frame Schedule on Drawings .

1. Doors:

a. Type: As indicated in the Door and Frame Schedule on Drawings.
b. Thickness: 1-3/4 inches (44.5 mm).
c. Face: Metallic-coated steel sheet, minimum thickness of 0.053 inch (1.3 mm).
d. Edge Construction: Model 1, Full Flush.
e. Core: Manufacturer's standard.
f. Fire-Rated Core: Manufacturer's standard vertical steel stiffener core for fire-rated and temperature-rise-rated doors.

F. Maximum-Duty Doors and Frames: ANSI/SDI A250.8, Level 4; ANSI/SDI A250.4, Level A. At locations indicated in the Door and Frame Schedule on Drawings.

1. Doors:

a. Type: As indicated in the Door and Frame Schedule on Drawings.
b. Thickness: 1-3/4 inches (44.5 mm).
c. Face: **Metallic-coated** steel sheet, minimum thickness of 0.067 inch (1.7 mm).
d. Edge Construction: Model 1, Full Flush.
e. Core: **Manufacturer's standard**
f. Fire-Rated Core: Manufacturer's standard **laminated mineral board** core for fire-rated **and temperature-rise-rated** doors.

## 2.4 BORROWED LITES

A. Fabricate of **uncoated** steel sheet, minimum thickness of **0.053 inch (1.3 mm)**.

B. Construction: **Full profile welded**.

C. Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections due to shipping or handling limitations, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as metal as frames.

D. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.

## 2.5 FRAME ANCHORS

A. Jamb Anchors:

1. Type: Anchors of minimum size and type required by applicable door and frame standard, and suitable for performance level indicated.
2. Quantity: Minimum of three anchors per jamb, with one additional anchor for frames with no floor anchor. Provide one additional anchor for each 24 inches (610 mm) of frame height above 7 feet (2.1 m).

B. Floor Anchors: Provide floor anchors for each jamb and mullion that extends to floor.

C. Material: ASTM A879/A879M, Commercial Steel (CS), 04Z (12G) coating designation; mill phosphatized.

## 2.6 MATERIALS

A. Cold-Rolled Steel Sheet: ASTM A1008/A1008M, Commercial Steel (CS), Type B; suitable for exposed applications.

B. Hot-Rolled Steel Sheet: ASTM A1011/A1011M, Commercial Steel (CS), Type B; free of scale, pitting, or surface defects; pickled and oiled.

C. Metallic-Coated Steel Sheet: ASTM A653/A653M, Commercial Steel (CS), Type B.

D. Inserts, Bolts, and Fasteners: Hot-dip galvanized in accordance with ASTM A153/A153M.

E. Power-Actuated Fasteners in Concrete: Fastener system of type suitable for application indicated, fabricated from corrosion-resistant materials, with clips or other accessory devices for attaching hollow-metal frames of type indicated.

F. Mineral-Fiber Insulation: ASTM C665, Type I (blankets without membrane facing); consisting of fibers manufactured from slag or rock wool; with maximum flame-spread and smoke-developed indexes of 25 and 50, respectively; passing ASTM E136 for combustion characteristics.

G. Glazing: Comply with requirements in Section 088000 "Glazing."

## 2.7 FABRICATION

A. Hollow-Metal Frames: Fabricate in one piece except where handling and shipping limitations require multiple sections. Where frames are fabricated in sections, provide alignment plates or angles at each joint, fabricated of metal of same or greater thickness as frames.
   1. Provide countersunk, flat- or oval-head exposed screws and bolts for exposed fasteners unless otherwise indicated.
   2. Door Silencers: Except on weather-stripped frames, drill stops to receive door silencers as follows. Keep holes clear during construction.

      a. Single-Door Frames: Drill stop in strike jamb to receive three door silencers.
      b. Double-Door Frames: Drill stop in head jamb to receive two door silencers.

B. Hardware Preparation: Factory prepare hollow-metal doors and frames to receive templated mortised hardware, and electrical wiring; include cutouts, reinforcement, mortising, drilling, and tapping in accordance with ANSI/SDI A250.6, the Door Hardware Schedule on Drawings, and templates.

   1. Reinforce doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.
   2. Comply with BHMA A156.115 for preparing hollow-metal doors and frames for hardware.

C. Glazed Lites: Provide stops and moldings around glazed lites where indicated. Form corners of stops and moldings with mitered hairline joints.

   1. Provide stops and moldings flush with face of door, and with beveled stops unless otherwise indicated.
   2. Multiple Glazed Lites: Provide fixed and removable stops and moldings so that each glazed lite is capable of being removed independently.
   3. Provide fixed frame moldings on outside of exterior and on secure side of interior doors and frames. Provide loose stops and moldings on inside of hollow-metal doors and frames.
   4. Coordinate rabbet width between fixed and removable stops with glazing and installation types indicated.
   5. Provide stops for installation with countersunk flat- or oval-head machine screws spaced uniformly not more than 9 inches (230 mm) o.c. and not more than 2 inches (51 mm) o.c. from each corner.

## 2.8 STEEL FINISHES

A. Prime Finish: Clean, pretreat, and apply manufacturer's standard primer.

   1. Shop Primer: Manufacturer's standard, fast-curing, lead- and chromate-free primer complying with ANSI/SDI A250.10; recommended by primer manufacturer for substrate; compatible with substrate and field-applied coatings despite prolonged exposure.

PART 3 - EXECUTION

3.1 PREPARATION

A. Remove welded-in shipping spreaders installed at factory. Restore exposed finish by grinding, filling, and dressing, as required to make repaired area smooth, flush, and invisible on exposed faces. Touch up factory-applied finishes where spreaders are removed.

B. Drill and tap doors and frames to receive nontemplated, mortised, and surface-mounted door hardware.

3.2 INSTALLATION

A. Hollow-Metal Frames: Comply with ANSI/SDI A250.11.

1. Set frames accurately in position; plumbed, aligned, and braced securely until permanent anchors are set. After wall construction is complete, remove temporary braces without damage to completed Work.

    a. Where frames are fabricated in sections, field splice at approved locations by welding face joint continuously; grind, fill, dress, and make splice smooth, flush, and invisible on exposed faces. Touch-up finishes.
    b. Install frames with removable stops located on secure side of opening.

2. Fire-Rated Openings: Install frames in accordance with NFPA 80.
3. Floor Anchors: Secure with postinstalled expansion anchors.

    a. Floor anchors may be set with power-actuated fasteners. Coordinate frame install with Owner.

4. Solidly pack mineral-fiber insulation inside frames.
5. Masonry Walls: Coordinate installation of frames to allow for solidly filling space between frames and masonry with grout or mortar.
6. Installation Tolerances: Adjust hollow-metal frames to the following tolerances:

    a. Squareness: Plus or minus 1/16 inch (1.6 mm), measured at door rabbet on a line 90 degrees from jamb perpendicular to frame head.
    b. Alignment: Plus or minus 1/16 inch (1.6 mm), measured at jambs on a horizontal line parallel to plane of wall.
    c. Twist: Plus or minus 1/16 inch (1.6 mm), measured at opposite face corners of jambs on parallel lines, and perpendicular to plane of wall.
    d. Plumbness: Plus or minus 1/16 inch (1.6 mm), measured at jambs at floor.

B. Hollow-Metal Doors: Fit and adjust hollow-metal doors accurately in frames, within clearances specified below.

1. Non-Fire-Rated Steel Doors: Comply with ANSI/SDI A250.8, NAAMM-HMMA 841 and NAAMM-HMMA guide specification indicated.
2. Fire-Rated Doors: Install doors with clearances in accordance with NFPA 80.

3. Smoke-Control Doors: Install doors in accordance with NFPA 105.

C. Glazing: Comply with installation requirements in Section 088000 "Glazing" and with hollow-metal manufacturer's written instructions.

## 3.3 FIELD QUALITY CONTROL

A. Inspection Agency: Architect/Engineer will perform field inspection to non-fire rated doors. Contractor will engage a quality inspector on-site for approval of fire-rated and egress door inspections.

B. Inspections:

1. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.
2. Egress Door Inspections: Inspect each door equipped with panic hardware, each door equipped with fire exit hardware, each door located in an exit enclosure, each electrically controlled egress door, and each door equipped with special locking arrangements in accordance with NFPA 101, Section 7.2.1.15.

C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.

D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

E. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80 and NFPA 101.

## 3.4 REPAIR

A. Prime-Coat Touchup: Immediately after erection, sand smooth rusted or damaged areas of prime coat and apply touchup of compatible air-drying, rust-inhibitive primer.

B. Metallic-Coated Surface Touchup: Clean abraded areas and repair with galvanizing repair paint in accordance with manufacturer's written instructions.

C. Touchup Painting: Cleaning and touchup painting of abraded areas of paint are specified in painting Sections.

END OF SECTION 081113

SECTION 081116.13 - INTERIOR ALUMINUM DOORS AND FRAMES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior aluminum doors and frames.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings:

1. Elevations, sections, and installation details for each wall-opening condition.
2. Details of construction of each component, including dimensioned profiles and metal thicknesses.
3. Locations of reinforcements and preparations for hardware.
4. Details of anchorages, joints, splices, connections, and accessories.
5. Details of trim, removable stops, and glazing.

C. Samples: Manufacturer's standard color sheets, showing full range of available colors for each type of exposed finish.

1.4 INFORMATIONAL SUBMITTALS

A. Oversize Fire-Rated Construction Certification: For assemblies required to be fire rated and exceeding limitations of labeled assemblies.

B. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. None.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Rated Door Assemblies: Complying with requirements in NFPA 80 and listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for fire-protection ratings indicated in schedules, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.

B. Smoke- and Draft-Control Door Assemblies: Listed and labeled for smoke and draft control based on testing in accordance with UL 1784 by a qualified testing agency acceptable to authorities having jurisdiction.

2.2 INTERIOR ALUMINUM DOORS AND FRAMES

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

1. Alpha Aluminum Architectural Products.
2. Avalon International Aluminum LLC.
3. Modulex Products, Inc.
4. Wilson Partitions; a division of Arcadia Inc.

B. Aluminum Framing: ASTM B221 (ASTM B221M), with alloy and temper required to suit structural and finish requirements, and not less than 0.062 inch (1.6 mm) thick.

C. Door Frames: Extruded aluminum, reinforced for hinges, strikes, and closers.

D. Aluminum-Framed Glass Doors: Manufacturer's standard, factory-assembled, 1-3/4-inch- (45-mm-) thick doors.

1. Stile Width: As indicated on Drawings.
2. Top-Rail Height: As indicated on Drawings.
3. Bottom-Rail Height: As indicated on Drawings.

2.3 ACCESSORIES

A. Fasteners: Aluminum, nonmagnetic, stainless steel, zinc-plated steel or other noncorrosive metal fasteners compatible with frames, stops, panels, reinforcement plates, hardware, anchors, and other items being fastened.

B. Corner Reinforcements and Alignment Clips: Manufacturer's standard concealed units to provide accurately fitted hairline joints at butted and mitered connections.

C. Door Silencers: Manufacturer's standard continuous mohair, wool pile, or vinyl seals, in manufacturer's standard color black.

D. Glazing Gaskets: Manufacturer's standard extruded or molded rubber or plastic, to accommodate glazing thickness indicated; in manufacturer's standard color black.

E. Glazing Stops: Removable to allow glazing replacement without framing disassembly.

F. Glass: As specified in Section 088000 "Glazing."

G. Door Hardware: As specified in Section 087100 "Door Hardware."

## 2.4 FABRICATION

A. Hardware Preparation: Factory prepare components to receive templated mortised hardware; include cutouts, reinforcements, mortising, drilling, and tapping.

1. Reinforce doors and frames to receive nontemplated mortised and surface-mounted hardware.
2. Locate hardware as indicated on Drawings.

B. Glazing Stops: Locate removable stops on inside of spaces accessed by locking doors.

C. Fabricate components to allow secure installation without exposed fasteners and to provide accurately fitted hairline joints at butted and mitered connections.

D. Fabricate frame components: 86 inches or shorter as one piece. Where splices are required, no individual piece may be less than 43 inches (1220 mm) long.

## 2.5 ALUMINUM FINISHES

A. Clear Anodic Finish: AAMA 611, AA-M12C22A41, Class I, 0.018 mm or thicker.

# PART 3 - EXECUTION

## 3.1 INSTALLATION OF ALUMINUM DOORS AND FRAMES

A. Install aluminum frames plumb, rigid, properly aligned, and securely fastened in place in accordance with manufacturer's written instructions.
1. Smoke- and Draft-Control Door Assemblies: Install in accordance with NFPA 105.

B. Glass: Install glass in accordance with Section 088000 "Glazing" and aluminum-frame manufacturer's written instructions.

C. Doors: Install doors aligned with frames and fitted with required hardware.

## 3.2 FIELD QUALITY CONTROL

A. Smoke- and Draft-Control Door Assembly Acceptance Testing: Owner to engage manufacturer’s inspection for installation. Test and inspect draft-control door assemblies in accordance with NFPA 105.

B. Prepare test and inspection reports.

## 3.3 ADJUSTING AND CLEANING

A. Doors: Adjust doors to operate smoothly and easily, without binding or warping. Adjust hardware to function smoothly in accordance with manufacturer's written instructions.

B. Clean exposed frame surfaces promptly after installation, using cleaning methods recommended in writing by frame manufacturer and in accordance with AAMA 609 & 610.

C. Touch Up: Immediately after installation, repair damaged areas of aluminum finishes and touchup in accordance with manufacturer's written instructions.

END OF SECTION 081116.13

SECTION 081416 - FLUSH WOOD DOORS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Solid-core flush wood doors with plastic-laminate-faces

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product, including the following:

   1. Door core materials and construction.
   2. Door edge construction
   3. Door face type and characteristics.
   4. Door louvers.
   5. Door trim for openings.
   6. Door frame construction.
   7. Factory-machining criteria.
   8. Factory-finishing specifications.

B. Shop Drawings: Indicate location, size, and hand of each door; elevation of each type of door; construction details not covered in Product Data; and the following:

   1. Door schedule indicating door and frame location, type, size, fire protection rating, and swing.
   2. Door elevations, dimension and locations of hardware, lite and louver cutouts, and glazing thicknesses.
   3. Details of frame for each frame type, including dimensions and profile.
   4. Details of electrical raceway and preparation for electrified hardware, access control systems, and security systems.
   5. Dimensions and locations of blocking for hardware attachment.
   6. Clearances and undercuts.
   7. Requirements for veneer matching.
   8. Apply AWI Quality Certification Program label to Shop Drawings.

C. Samples: None

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For door inspector.

   1. Fire-Rated Door Inspector: Submit documentation of compliance with NFPA 80, Section 5.2.3.1.
   2. Egress Door Inspector: Submit documentation of compliance with NFPA 101, Section 7.2.1.15.4.

B. Field quality-control reports.

1.4 CLOSEOUT SUBMITTALS

A. Quality Standard Compliance Certificates: AWI Quality Certification Program certificates.

B. Record Documents: For fire-rated doors, list of door numbers and applicable room name and number to which door accesses.

1.5 QUALITY ASSURANCE

A. None:

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Rated Wood Door and Frame Assemblies: Assemblies complying with NFPA 80 that are listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction, for fire-protection ratings and temperature-rise limits indicated on Drawings, based on testing at positive pressure in accordance with UL 10C or NFPA 252.

2.2 FLUSH WOOD DOORS AND FRAMES, GENERAL

A. Quality Standard: In addition to requirements specified, comply with ANSI/WDMA I.S. 1A.

2.3 SOLID-CORE FLUSH WOOD DOORS WITH PLASTIC-LAMINATE FACES

A. Interior Doors, Solid Core with Plastic-Laminate Faces:

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

    a. ABS- American Building Supply- Doormerica.
    b. Lambton Doors.
    c. Masonite Architectural.
    d. Oshkosh Door Company.
    e. VT Industries, Inc.
    f. Vancouver Door Company.
2. Performance Grade: ANSI/WDMA I.S. 1A as indicated on Drawings.
3. Performance Grade by Location:

    a. ANSI/WDMA I.S. 1A Extra Heavy Duty: Staff toilets, janitor's closets and where indicated on Drawings.
    b. ANSI/WDMA I.S. 1A Standard Duty: Closets (not including janitor's closets) and where indicated on Drawings.

4. ANSI/WDMA I.S. 1A Grade: Premium.
5. Plastic-Laminate Faces: High-pressure decorative laminates complying with ISO 4586-3, Grade HGS or Grade HSH.
6. Colors, Patterns, and Finishes: As selected by Architect from laminate manufacturer's full range of products.
7. Exposed Vertical and Top Edges: Plastic laminate that matches faces, applied before faces.

    a. Fire-Rated Single Doors: Provide edge construction with intumescent seals concealed by outer stile. Comply with specified requirements for exposed vertical edges.
    b. Fire-Rated Pairs of Doors:

        1) Provide fire-retardant stiles that are listed and labeled for applications indicated without formed-steel edges and astragals. Provide stiles with concealed intumescent seals. Comply with specified requirements for exposed edges.

        2) Screw-Holding Capability: 550 lbf (2440 N) in accordance with WDMA T.M. 10.

8. Core for Non-Fire-Rated Doors:

    a. ANSI A208.1, Grade LD-1 particleboard.

    b. Glued wood stave.
    c. WDMA I.S. 10 structural composite lumber.

        1) Screw Withdrawal, Face: 550 lbf (2440 N).
        2) Screw Withdrawal, Edge: 550 lbf (2440 N).

    d. Either glued wood stave or WDMA I.S. 10 structural composite lumber.

9. Core for Fire-Rated Doors: As required to achieve fire-protection rating indicated on Drawings.

    a. Blocking for Mineral-Core Doors: Provide composite blocking with improved screw-holding capability approved for use in doors of fire-protection ratings indicated on Drawings as needed to eliminate through-bolting hardware.

        1) 5-inch (125-mm) top-rail blocking.
        2) 5-inch (125-mm) bottom-rail blocking, in doors indicated to have protection plates.
        3) 5-inch (125-mm) midrail blocking, in doors indicated to have armor plates.
        4) 5-inch (125-mm) midrail blocking, in doors indicated to have exit devices.

10. Construction:
    a. Five plies, hot-pressed or cold-pressed bonded (vertical and horizontal edging is bonded to core), with entire unit abrasive planed before faces and crossbands are applied.

## 2.4 FABRICATION

A. Factory fit doors to suit frame-opening sizes indicated.

1. Comply with clearance requirements of referenced quality standard for fitting unless otherwise indicated.
2. Comply with NFPA 80 requirements for fire-rated doors.

B. Factory machine doors for hardware that is not surface applied.

1. Locate hardware to comply with DHI-WDHS-3.
2. Comply with final hardware schedules, door frame Shop Drawings, ANSI/BHMA-156.115-W, and hardware templates.
3. Coordinate with hardware mortises in metal frames, to verify dimensions and alignment before factory machining.
4. For doors scheduled to receive electrified locksets, provide factory-installed raceway and wiring to accommodate specified hardware.

C. Openings: Factory cut and trim openings through doors.

1. Light Openings: Trim openings with moldings of material and profile indicated.
2. Glazing: Factory install glazing in doors indicated to be factory finished. Comply with applicable requirements in Section 088000 "Glazing."
3. Louvers: Factory install louvers in prepared openings.

## 2.5 FACTORY FINISHING

A. Comply with referenced quality standard for factory finishing.

1. Complete fabrication, including fitting doors for openings and machining for hardware that is not surface applied, before finishing.
2. Finish faces, all four edges, edges of cutouts, and mortises.
3. Stains and fillers may be omitted on[ top and] bottom edges, edges of cutouts, and mortises.

B. Factory finish doors.

C. Factory finish doors that are indicated on Drawings to receive transparent finish.

1. ANSI/WDMA I.S. 1A Grade: Premium.
2. Staining: As selected by Architect from manufacturer's full range.
3. Sheen: Satin.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Hardware: For installation, see Section 087100 "Door Hardware."

B. Install doors to comply with manufacturer's written instructions and referenced quality standard, and as indicated.

C. Install frames level, plumb, true, and straight.

1. Shim as required with concealed shims. Install level and plumb to a tolerance of 1/8 inch in 96 inches (3.2 mm in 2400 mm).
2. Anchor frames to anchors or blocking built in or directly attached to substrates.

    a. Secure with countersunk, concealed fasteners and blind nailing.
    b. Use fine finishing nails or finishing screws for exposed fastening, countersunk and filled flush with woodwork.

        1) For factory-finished items, use filler matching finish of items being installed.

3. Install fire-rated doors and frames in accordance with NFPA 80.
4. Install smoke- and draft-control doors in accordance with NFPA 105.

D. Job-Fitted Doors:

1. Align and fit doors in frames with uniform clearances and bevels as indicated below.

    a. Do not trim stiles and rails in excess of limits set by manufacturer or permitted for fire-rated doors.

2. Machine doors for hardware.
3. Seal edges of doors, edges of cutouts, and mortises after fitting and machining.
4. Clearances:

    a. Provide 1/8 inch (3.2 mm) at heads, jambs, and between pairs of doors.
    b. Provide 1/8 inch (3.2 mm) from bottom of door to top of decorative floor finish or covering unless otherwise indicated on Drawings.
    c. Where threshold is shown or scheduled, provide 1/4 inch (6.4 mm) from bottom of door to top of threshold unless otherwise indicated.
    d. Comply with NFPA 80 for fire-rated doors.

5. Bevel non-fire-rated doors 1/8 inch in 2 inches (3-1/2 degrees) at lock and hinge edges.
6. Bevel fire-rated doors 1/8 inch in 2 inches (3-1/2 degrees) at lock edge; trim stiles and rails only to extent permitted by labeling agency.

E. Factory-Fitted Doors: Align in frames for uniform clearance at each edge.

F. Factory-Finished Doors: Restore finish before installation if fitting or machining is required at Project site.

## 3.2 FIELD QUALITY CONTROL

A. Inspection Agency: Architect/Engineer to perform field inspections and to furnish reports to Owner on non-fire rated door assemblies only. Owner to engage an inspection on fire-rated and smoke controlled door assemblies.

B. Inspections:
   1. Fire-Rated Door Inspections: Inspect each fire-rated door in accordance with NFPA 80, Section 5.2.
   2. Egress Door Inspections: Inspect each door equipped with panic hardware, each door equipped with fire exit hardware, each door located in an exit enclosure, each electrically controlled egress door, and each door equipped with special locking arrangements in accordance with NFPA 101, Section 7.2.1.15.

C. Repair or remove and replace installations where inspections indicate that they do not comply with specified requirements.

D. Reinspect repaired or replaced installations to determine if replaced or repaired door assembly installations comply with specified requirements.

E. Prepare and submit separate inspection report for each fire-rated door assembly indicating compliance with each item listed in NFPA 80 and NFPA 101.

## 3.3 ADJUSTING

A. Operation: Rehang or replace doors that do not swing or operate freely.

B. Finished Doors: Replace doors that are damaged or that do not comply with requirements. Doors may be repaired or refinished if Work complies with requirements and shows no evidence of repair or refinishing.

END OF SECTION 081416

SECTION 087100 - DOOR HARDWARE

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Hinges.
2. Continuous, pin-and-barrel-type hinges.
3. Bored locks.
4. Mortise locks.
5. Electric strikes.
6. Electromagnetic locks.
7. Exit locks and alarms.
8. Exit devices and auxiliary items.
9. Lock cylinders.
10. Key control cabinet.
11. Coordinators.
12. Surface closers.
13. Closer holder release devices.
14. Wall- and floor-mounted stops.
15. Door gasketing.
16. Thresholds.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

B. Keying Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: For electrified door hardware.

1. Diagrams for power, signal, and control wiring.
2. Details of interface of electrified door hardware and building safety and security systems.

C. Samples: For each exposed product in each finish specified.

D. Door hardware schedule.

E. Keying schedule.

## 1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample warranty.

## 1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

## 1.6 QUALITY ASSURANCE

A. Installer Qualifications: Supplier of products and an employer of workers trained and approved by product manufacturers and of an Architectural Hardware Consultant who is available during the course of the Work to consult Contractor, Architect, and Owner about door hardware and keying.

1. Scheduling Responsibility: Preparation of door hardware and keying schedule.
2. Engineering Responsibility: Preparation of data for electrified door hardware, including Shop Drawings, based on testing and engineering analysis of manufacturer's standard units in assemblies similar to those indicated for this Project.

B. Architectural Hardware Consultant Qualifications: A person who is experienced in providing consulting services for door hardware installations that are comparable in material, design, and extent to that indicated for this Project and who is currently certified by DHI as an Architectural Hardware Consultant (AHC).

## 1.7 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of door hardware that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Three years from date of Substantial Completion unless otherwise indicated below:
   a. Exit Devices: Two years from date of Substantial Completion.
   b. Manual Closers: 10 years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 SOURCE LIMITATIONS

A. Obtain each type of door hardware from single manufacturer.

1. Provide electrified door hardware from same manufacturer as mechanical door hardware unless otherwise indicated. Manufacturers that perform electrical modifications and that are listed by a testing and inspecting agency acceptable to authorities having jurisdiction are acceptable.

## 2.2 PERFORMANCE REQUIREMENTS

A. Fire-Rated Door Assemblies: Where fire-rated doors are indicated, provide door hardware complying with NFPA 80 that is listed and labeled by a qualified testing agency, for fire-protection ratings indicated, based on testing at positive pressure in accordance with NFPA 252 or UL 10C.

B. Smoke- and Draft-Control Door Assemblies: Where smoke- and draft-control door assemblies are required, provide door hardware that complies with requirements of assemblies tested in accordance with UL 1784 and installed in compliance with NFPA 105.

1. Air-Leakage Rate: Maximum air leakage of 0.3 cfm per sq. ft. (3 cu. m per minute/sq. m) at the tested pressure differential of 0.3 inch wg (75 Pa) of water.

C. Electrified Door Hardware: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Means of Egress Doors: Latches do not require more than 15 lbf (67 N) to release the latch. Locks do not require use of a key, tool, or special knowledge for operation.

E. Accessibility Requirements: For door hardware on doors in an accessible route, comply with the USDOJ's "2010 ADA Standards for Accessible Design", the ABA standards of the Federal agency having jurisdiction and ICC A117.1.

## 2.3 HINGES

A. Hinges: ANSI/BHMA A156.1. Provide template-produced hinges for hinges installed on hollow-metal doors and hollow-metal frames.

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

a. Allegion plc.
b. Design Hardware; Mesker Openings Group; dormakaba.
c. Hager Companies.
d. McKinney Products Company; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.
e. STANLEY; dormakaba USA, Inc.

## 2.4 CONTINUOUS HINGES

A. Continuous, Pin-and-Barrel-Type Hinges: ANSI/BHMA A156.26; minimum 0.120-inch- (3.0-mm-) thick, hinge leaves with minimum overall width of 4 inches (102 mm); fabricated to full height of door and frame and to template screw locations; with components finished after milling and drilling are complete.

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

a. Allegion plc.

b. Hager Companies.
c. McKinney Products Company; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.
d. STANLEY; dormakaba USA, Inc.

## 2.5 ELECTRIC STRIKES

A. Electric Strikes: ANSI/BHMA A156.31, Grade 1; with faceplate to suit lock and frame.

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

a. ASSA ABLOY Electronic Security Hardware; ASSA ABLOY.
b. Allegion plc.
c. Hager Companies.
d. STANLEY; dormakaba USA, Inc.

## 2.6 ELECTROMAGNETIC LOCKS

A. Electromagnetic Locks: ANSI/BHMA A156.23; electrically powered; with electromagnet attached to frame and armature plate attached to door; full-exterior or full-interior type, as required by application indicated.

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

a. ASSA ABLOY Electronic Security Hardware; ASSA ABLOY.
b. Allegion plc.
c. Dortronics Systems, Inc.
d. Hager Companies.

## 2.7 EXIT LOCKS AND EXIT ALARMS

A. Exit Locks and Alarms: ANSI/BHMA A156.29, Grade 1.

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

a. Arrow USA; an ASSA ABLOY Group company.
b. Detex Corporation.
c. Precision Hardware, Inc.; dormakaba Group.
d. SARGENT Manufacturing Company; ASSA ABLOY.

## 2.8 EXIT DEVICES AND AUXILIARY ITEMS

A. Exit Devices and Auxiliary Items: ANSI/BHMA A156.3.

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

a. Allegion plc.
b. C.R. Laurence Co., Inc.; CRH Americas, Inc.
c. Corbin Russwin, Inc.; an ASSA ABLOY Group company.
d. Hager Companies.

2.9 LOCK CYLINDERS

A. Lock Cylinders: Tumbler type, constructed from brass or bronze, stainless steel, or nickel silver. Provide cylinder from same manufacturer of locking devices.

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

a. ASSA, Inc.
b. Allegion plc.
c. Hager Companies.
d. SARGENT Manufacturing Company; ASSA ABLOY.

B. Standard Lock Cylinders: ANSI/BHMA A156.5, Grade 1 permanent cores; face finished to match lockset.

1. Core Type: Interchangeable.

C. High-Security Lock Cylinders: ANSI/BHMA A156.30, Grade 1 permanent cores that are removable; face finished to match lockset.

1. Type E, electrical.

D. Construction Master Keys: Provide cylinders with feature that permits voiding of construction keys without cylinder removal. Provide 10 construction master keys.

2.10 KEYING

A. Keying System: Factory registered, complying with guidelines in ANSI/BHMA A156.28, appendix. Provide one extra key blank for each lock. Incorporate decisions made in keying conference.

1. Master Key System: Change keys and a master key operate cylinders.

a. Provide three cylinder change keys and five master keys.

2. Existing System:

a. Master key or grand master key locks to Owner's existing system.

3. Keyed Alike: Key all cylinders to same change key.

B. Keys: Nickel silver.

1. Stamping: Permanently inscribe each key with a visual key control number and include the following notation:

a. Notation: **Information to be furnished by Owner.**

2.11 OPERATING TRIM

A. Operating Trim: ANSI/BHMA A156.6; aluminum unless otherwise indicated.

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

a. Allegion plc.
b. Hager Companies.
c. Rockwood Manufacturing Company; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.
d. Trimco.

2.12 SURFACE CLOSERS

A. Surface Closers: ANSI/BHMA A156.4; rack-and-pinion hydraulic type with adjustable sweep and latch speeds controlled by key-operated valves and forged-steel main arm. Comply with manufacturer's written instructions for size of door closers depending on size of door, exposure to weather, and anticipated frequency of use. Provide factory-sized closers, adjustable to meet field conditions and requirements for opening force.

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

a. Allegion plc.
b. Corbin Russwin, Inc.; an ASSA ABLOY Group company.
c. Hager Companies.
d. SARGENT Manufacturing Company; ASSA ABLOY.
e. STANLEY; dormakaba USA, Inc.
f. Yale Security Inc; ASSA ABLOY.

2.13 MECHANICAL STOPS AND HOLDERS

A. Wall- and Floor-Mounted Stops: ANSI/BHMA A156.16.

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

a. Allegion plc.
b. Hager Companies.
c. Rockwood Manufacturing Company; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.

## 2.14 ELECTROMAGNETIC STOPS AND HOLDERS

A. Electromagnetic Door Holders: ANSI/BHMA A156.15, Grade 1; wall-mounted electromagnetic single unit with strike plate attached to swinging door; coordinated with fire detectors and interfaced with fire-alarm system for labeled fire-rated door assemblies.

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

   a. Allegion plc.
   b. Hager Companies.
   c. SARGENT Manufacturing Company; ASSA ABLOY.

## 2.15 DOOR GASKETING

A. Door Gasketing: ANSI/BHMA A156.22; with resilient or flexible seal strips that are easily replaceable and readily available from stocks maintained by manufacturer.

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

   a. Hager Companies.
   b. Legacy Manufacturing.
   c. Pemko Manufacturing Company Inc.; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.

B. Maximum Air Leakage: When tested in accordance with ASTM E283/E283M with tested pressure differential of 0.3 inch wg (75 Pa), as follows:
   1. Gasketing on Single Doors: 0.3 cfm/sq. ft. (3 cu. m per minute/sq. m) of door opening.

## 2.16 THRESHOLDS

A. Thresholds: ANSI/BHMA A156.21; fabricated to full width of opening indicated.

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

   a. Hager Companies.
   b. Pemko Manufacturing Company Inc.; ASSA ABLOY Accessories and Door Controls Group, Inc.; ASSA ABLOY.
   c. Rixson Specialty Door Controls; ASSA ABLOY.
   d. Zero International; Allegion plc.

## 2.17 FINISHES

A. Provide finishes complying with ANSI/BHMA A156.18 as indicated in door hardware schedule.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Mounting Heights: Mount door hardware units at heights indicated on Drawings to comply with the following unless otherwise indicated or required to comply with governing regulations.

1. Standard Steel Doors and Frames: ANSI/SDI A250.8.
2. Custom Steel Doors and Frames: HMMA 831.
3. Wood Doors: DHI's "Recommended Locations for Architectural Hardware for Wood Flush Doors."

B. Install each door hardware item to comply with manufacturer's written instructions. Where cutting and fitting are required to install door hardware onto or into surfaces that are later to be painted or finished in another way, coordinate removal, storage, and reinstallation of surface protective trim units with finishing work. Do not install surface-mounted items until finishes have been completed on substrates involved.

C. Hinges: Install types and in quantities indicated in door hardware schedule, but not fewer than the number recommended by manufacturer for application indicated or one hinge for every 30 inches (760 mm) of door height, whichever is more stringent, unless other equivalent means of support for door, such as spring hinges or pivots, are provided.

D. Intermediate Offset Pivots: Where offset pivots are indicated, provide intermediate offset pivots in quantities indicated in door hardware schedule, but not fewer than one intermediate offset pivot per door and one additional intermediate offset pivot for every 30 inches (760 mm) of door height greater than 90 inches (2286 mm).

E. Lock Cylinders: Install construction cores to secure building and areas during construction period.

1. Replace construction cores with permanent cores as indicated in keying schedule directed by Owner.

F. Boxed Power Supplies: Locate power supplies as indicated or, if not indicated, in equipment room. Verify location with Architect.

1. Configuration: Provide least number of power supplies required to adequately serve doors with electrified door hardware.

G. Thresholds: Set thresholds for exterior doors and other doors indicated in full bed of sealant complying with requirements specified in Section 079200 "Joint Sealants."

H. Stops: Provide floor stops for doors unless wall or other type stops are indicated in door hardware schedule. Do not mount floor stops where they will impede traffic.

I. Perimeter Gasketing: Apply to head and jamb, forming seal between door and frame.

1. Do not notch perimeter gasketing to install other surface-applied hardware.

J. Meeting Stile Gasketing: Fasten to meeting stiles, forming seal when doors are closed.

K. Door Bottoms: Apply to bottom of door, forming seal with threshold when door is closed.

## 3.2 FIELD QUALITY CONTROL

A. Independent Architectural Hardware Consultant: Engage a qualified independent Architectural Hardware Consultant to perform inspections and to prepare inspection reports.

1. Independent Architectural Hardware Consultant will inspect door hardware and state in each report whether installed work complies with or deviates from requirements, including whether door hardware is properly installed and adjusted.

## 3.3 ADJUSTING

A. Initial Adjustment: Adjust and check each operating item of door hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate as intended. Adjust door control devices to compensate for final operation of heating and ventilating equipment and to comply with referenced accessibility requirements.

## 3.4 DOOR HARDWARE SCHEDULE

1. Refer to Door Hardware Sets and Door Schedule for more information.

END OF SECTION 087100

## Set: HW-SF-1

Door: 100A

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | EXISTING | | | |
| 1 | Passage Latch | EXISTING | | | |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |
| 1 | Sweep | REPLACE EXISTING | | | |
| 1 | Transition Strip | REPLACE EXISTING | | | |

Notes: *Waiver may be required to comply with Buy American Act.

Operation:
• Door is normally closed and latched with Passage set.

## Set: HW-SH-1

Doors: 100B.2, 102A, 102B, 104A and 104B

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Fail Safe Lock (Locks Both Levers)* | BAA RX 72 8272-24V LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surf Overhead Stop (CO2541)* | 9-X36 | 630 | RF | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American-type regulations must be validated with the manufacturer.
Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and secure.
• When a proper credential is presented to the Card Reader (by Others) the lever on both sides of the opening will be momentarily released to allow entry, and coordinated with interlocking electromechanical hardware sets in Doors 100B.2, 102A, 102B, 104A and 104B. Locksets can be daisy chained and operate in separate pairs.
• Request to Exit Switch integrated in lockset will signal an authorized egress to access control system.
• Key outside retracts latch.
• Lock is Fail Safe and will remain unlocked in the event of a fire emergency or power outage.
• Door position switch will signal the doors OPEN/CLOSED status to the access control panel.

## Set: HW-SH-2A

Doors: 107, 114, C103

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8112)* | TA2714 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Fail Safe Lock* | BAA RX 72 8270-24V LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Card Reader* | BY SECURITY INTEGRATOR | | | |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American type regulations must be validated with the manufacturer. Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and secure.
• When a proper credential is presented to the Card Reader (by Others) the lever on the unsecure side of the opening will b momentarily released to allow entry.
• The lever on the secure side is free at all times for egress. Request to Exit Switch integrated in lockset will signal an authorized egress to access control system.
• Key outside retracts latch.
• Lock is Fail Safe and will unlock in the event of a fire emergency or power outage.
Door position switch will signal the doors OPEN/CLOSED status to the access control panel.
• Door is integrated with door signal light. Refer to Electrical Drawings.

## Set: HW-SH-2B

Doors: 100B.1, 101, 109, 110B.1

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8112)* | TA2714 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Fail Safe Lock* | BAA RX 72 8270-24V LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |

| | | | | |
|---|---|---|---|---|
| 1 | Existing Card Reader | EXISTING CARD READER | | |
| 1 | Position Switch (E08)* | DPS-M-BK | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | SU | 087100 |

Operation:
• Door is normally closed and secure.
• When a proper credential is presented to the Card Reader (by Others) the lever on the unsecure side (outside lever) of the opening will be momentarily released to allow entry.
• The lever on the secure side is free at all times for egress.
• Key outside retracts latch.
• Lock is Fail Safe and will unlock in the event of a fire emergency or power outage.
• Door position switch will signal the doors OPEN/CLOSED status to the access control panel.
• Door is integrated with door signal light. Refer to Electrical Drawings.

**Set: HW-2A**

Doors: 103B, 106

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8112) | TA2714 x USA | US26D | MK | 087100 |
| 1 | Storeroom Lock (F07) | 72 8204 LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |

Notes: * Waiver may be required to comply with Buy American Act.

**Set: HW-SH-3**

Doors: 104C

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Fail Secure Lock* | BAA RX 72 8271-24V LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surf Overhead Stop (CO2541)* | 9-X36 | 630 | RF | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |
| 1 | Card Reader* | BY SECURITY INTEGRATOR | | | |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Operation:
• Door is normally closed and secure.

• When a proper credential is presented to the Card Reader (by Others) the lever on the unsecure side (outside lever) of the opening will be momentarily released to allow entry.
• The lever on the secure side is free at all times for egress.
• Key outside retracts latch.
• Lock is Fail Safe and will unlock in the event of a fire emergency or power outage.
• Door position switch will signal the doors OPEN/CLOSED status to the access control panel.
• Door is integrated with door signal light. Refer to Electrical Drawings.

**Set: HW-SH-4**

Doors: 102C, 104D

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8112)* | TA2714 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Fail Safe Lock* | BAA RX 72 8270-24V LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Emergency Push Button | BY SECURITY INTEGRATOR (ROUGH-IN) | | | |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American-type regulations must be validated with the manufacturer. Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and secure.
• The lever on the secure side is free at all times for egress. Request to Exit Switch integrated in lockset will signal an authorized egress to access control system.
• An Emergency Push Button device to be mounted adjacent opening on the latch secure side.
• Key outside retracts latch.
• Lock is Fail Safe and will unlock in the event of a fire emergency or power outage.
Door position switch will signal the doors OPEN/CLOSED status to the access control panel.
• Door is integrated with door signal light. Refer to Electrical Drawings.

**Set: HW-SH-4A**

Doors: 105B

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8112)* | TA2714 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |

| | | | | | |
|---|---|---|---|---|---|
| 1 | Fail Safe Lock* | BAA RX 72 8270-24V LNL | US26D | SA | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Rim Exit Device (Type 1, E10, Less Dogging) | BAA LD 43 8815 AL | 626 | SA | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American-type regulations must be validated with the manufacturer. Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and secure.
• The rim exit device is on the secure side is free at all times for egress.
• Key outside retracts latch.
• Door is an Exit Only/Blank Plate
• Delayed Egress Alarmed Exit when in locked position
• Lock is Fail Safe and will unlock in the event of a fire emergency or power outage.
• Door position switch will signal the doors OPEN/CLOSED status to the access control panel.

**Set: HW-SH-4B**

Doors: 105A

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Rim Exit Device (Type 1, 14, E06, Less Dogging) | BAA LD 43 56 8815 ETL | 626 | SA | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Harness Adaptor* | 52-2946 | | SA | |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act.
Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and latched. Exit Device is a rim exit device with electromechanical fail safe lockset
• Manual entry or egress is always available by turning the exit device lever trim or pressing the exit device push bar.
• The exit device is fail safe and will remain latched unsecure in the absence of power.
.

**Set: HW-4**

Doors: 112, 115, 120A, 120B, 120C, 120D, 120E

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Office Lock (F05) | BAA 72 8255 LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | US26D | BE | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |

**Set: HW-SH-5A**

Doors: C105A

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US32D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Rim Exit Device (Type 1, E01, E05, Less Dogging)* | LD 55 72 BAA 8875-24v ETL | 626 | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 1 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Harness Adaptor* | 52-2946 | | SA | |
| 1 | Card Reader* | BY SECURITY INTEGRATOR | | | |
| 1 | Position Switch (E08)* | DPS-M-BK | | SU | 087100 |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act.
Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and latched.
• Exit Device has Nightlatch Function (Key will retract the exit device latch, door is latched when the key is removed).
• When an authorized card read is detected on the Pull side of the door the access control system will momentarily release the exit device trim lever to allow authorized entry.
• Manual egress is always available by pressing the exit device push bar. Request to Exit Switch in Exit Device
push bar will signal an authorized egress to access control system.
• The exit device trim is fail secure and will remain locked in the absence of power.
• Door position switch will signal the doors OPEN/CLOSED status to the access control panel.

**Set: HW-SH-5B**

Doors: C105B, 105A

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Electric Power Transfer* | EL-CEPT | 630 | SU | 087100 |
| 1 | Rim Exit Device (Type 1, 14, E06, Less Dogging) | BAA LD 43 56 8815 ETL | 626 | SA | 087100 |
| 1 | Electromagnetic Door Holder | 1505-AQN5 – Fail Safe | 689 | ES | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |
| 1 | Frame Harness | QC-C1500P | | MK | 087100 |
| 1 | Door Harness | QC-C___ | | MK | 087100 |
| 1 | Harness Adaptor* | 52-2946 | | SA | |
| 1 | Power Supply* | AQDxx (TO SUIT) | | SU | 087100 |

Notes: *Waiver may be required to comply with Buy American Act.
Coordinate all Wiring and conduit with electrical contractor.

Operation:
• Door is normally closed and latched. Exit Device is a rim exit device with electromechanical fail safe lockset
• Door C105B is held on electromagnetic door holder only and can bypass fire alarm release with card reader. Electromagnetic lockset is interlocked with Door C105A.
• Manual entry or egress is always available by turning the exit device lever trim or pressing the exit device push bar.
• The exit device is fail safe and will remain latched unsecure in the absence of power.
.

**Set: HW-4**

Doors: 112, 115, 120A, 120B, 120C, 120D, 120E

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Office Lock (F05) | BAA 72 8255 LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | US26D | BE | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American type regulations must be validated with the manufacturer.

**Set: HW-5**

Doors: 108B

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Storeroom Lock (F05) | BAA 72 8206 LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | US26D | BE | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American type regulations must be validated with the manufacturer.

**Set: HW-7**

Doors: 111, 113

| | | | | | |
|---|---|---|---|---|---|
| 6 | Hinge (A8111) | T4A3786 x USA | US32D | MK | 087100 |
| 2 | Self Latching Flush Bolt (Type 27) | 2805/2905 | US32D | RO | 087100 |
| 1 | Storeroom/Closet Lock (F07) | BAA 72 8204 LNL | US32D | SA | 087100 |
| 2 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | 26 | BE | 087100 |
| 2 | Surface Closer (C02021-PT4G)* | CPS8501 M | 689 | NO | 087100 |
| 2 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Astragal (R0Y634) | 357C | | PE | 087100 |
| 1 | Adhesive Gasketing (R0Y154) | S88BL | | PE | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American type regulations must be validated with the manufacturer.

**Set: HW-8**

Doors: 120A, 120B, 120C, 120D, 120E

| | | | | | |
|---|---|---|---|---|---|
| 3 | Hinge (A8111) | T4A3786 x USA | US26D | MK | 087100 |
| 1 | Passage Lock (F05) | BAA 72 8215 LNL | US26D | SA | 087100 |
| 1 | Interchangeable Core (E09241) * | SFIC 6-Pin Core (by Owner) | US26D | BE | 087100 |
| 1 | Surface Closer (C02011 / C02021)* | R / PR8501 M | 689 | NO | 087100 |
| 1 | Kick Plate (J102) | K1050 10" CSK | US32D | RO | 087100 |
| 1 | Door Stop (L02251/L02121)* | 403 / 470 | US26D | RO | 087100 |
| 3 | Silencer (L03011)* | 608 | | RO | 087100 |

Notes: *Waiver may be required to comply with Buy American Act. Compliancy of this product to current Buy American-type regulations must be validated with the manufacturer.

SECTION 088000 - GLAZING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Glass products.
2. Glazing sealants.
3. Glazing tapes.
4. Miscellaneous glazing materials.

1.2 COORDINATION

A. Coordinate glazing channel dimensions to provide necessary bite on glass, minimum edge and face clearances, and adequate sealant thicknesses, with reasonable tolerances to achieve proper safety margins for glazing retention under each design load case, load case combination, and service condition.

1.3 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Glass Samples: For each type of glass product other than clear monolithic vision glass; 12 inches (300 mm) square.

1.5 INFORMATIONAL SUBMITTALS

A. Product Certificates: For glass.

B. Product test reports.

C. Preconstruction adhesion and compatibility test report.

D. Sample warranties.

## 1.6 QUALITY ASSURANCE

A. Sealant Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021 to conduct the testing indicated.

## 1.7 WARRANTY

A. Manufacturer's Special Warranty for Laminated Glass: Manufacturer agrees to replace laminated-glass units that deteriorate within specified warranty period. Deterioration of laminated glass is defined as defects developed from normal use that are not attributed to glass breakage or to maintaining and cleaning laminated glass contrary to manufacturer's written instructions. Defects include edge separation, delamination materially obstructing vision through glass, and blemishes exceeding those allowed by referenced laminated-glass standard.

1. Warranty Period: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 PERFORMANCE REQUIREMENTS

A. Safety Glazing: Where safety glazing is indicated, provide glazing that complies with 16 CFR 1201, Category II.

B. Acoustic Performance:
1. Interior Glazing: 35 STC.

## 2.2 GLASS PRODUCTS, GENERAL

A. Glazing Publications: Comply with published recommendations of glass product manufacturers and organizations below unless more stringent requirements are indicated. See these publications for glazing terms not otherwise defined in this Section or in referenced standards.

1. NGA Publications: "Laminated Glazing Reference Manual" and "Glazing Manual."

B. Safety Glazing Labeling: Where safety glazing is indicated, permanently mark glazing with certification label of the SGCC or another certification agency acceptable to authorities having jurisdiction or manufacturer. Label shall indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

C. Thickness: Where glass thickness is indicated, it is a minimum. Provide glass that complies with performance requirements and is not less than thickness indicated.

## 2.3 GLASS PRODUCTS

A. Fully Tempered Float Glass: ASTM C1048, Kind FT (fully tempered), Condition A (uncoated) unless otherwise indicated, Type I, Class 1 (clear) or Class 2 (tinted) as indicated, Quality-Q3.

## 2.4 GLAZING SEALANTS

A. General:

1. Compatibility: Compatible with one another and with other materials they contact, including glass products, seals of insulating-glass units, and glazing channel substrates, under conditions of service and application, as demonstrated by sealant manufacturer based on testing and field experience.
2. Suitability: Comply with sealant and glass manufacturers' written instructions for selecting glazing sealants suitable for applications indicated and for conditions existing at time of installation.
3. Colors of Exposed Glazing Sealants: As selected by Architect from manufacturer's full range of industry colors.

## 2.5 GLAZING TAPES

A. Back-Bedding Mastic Glazing Tapes: Preformed, butyl-based, 100 percent solids elastomeric tape; nonstaining and nonmigrating in contact with nonporous surfaces; with or without spacer rod as recommended in writing by tape and glass manufacturers for application indicated; and complying with ASTM C1281 and AAMA 800 for products indicated below:

1. AAMA 804.3 tape, where indicated.

## 2.6 MISCELLANEOUS GLAZING MATERIALS

A. Cleaners, Primers, and Sealers: Types recommended by sealant or gasket manufacturer.

# PART 3 - EXECUTION

## 3.1 GLAZING, GENERAL

A. Comply with combined written instructions of manufacturers of glass, sealants, gaskets, and other glazing materials, unless more stringent requirements are indicated, including those in referenced glazing publications.

B. Protect glass edges from damage during handling and installation. Remove damaged glass from Project site and legally dispose of off Project site. Damaged glass includes glass with edge damage or other imperfections that, when installed, could weaken glass, impair performance, or impair appearance.

C. Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction testing.

D. Install setting blocks in sill rabbets, sized and located to comply with referenced glazing publications, unless otherwise required by glass manufacturer. Set blocks in thin course of compatible sealant suitable for heel bead.

E. Do not exceed edge pressures stipulated by glass manufacturers for installing glass lites.

F. Provide spacers for glass lites where length plus width is larger than 50 inches (1270 mm).

G. Provide edge blocking where indicated or needed to prevent glass lites from moving sideways in glazing channel, as recommended in writing by glass manufacturer and in accordance with requirements in referenced glazing publications.

## 3.2 TAPE GLAZING

A. Position tapes on fixed stops so that, when compressed by glass, their exposed edges are flush with or protrude slightly above sightline of stops.

B. Install tapes continuously, but not necessarily in one continuous length. Do not stretch tapes to make them fit opening.

C. Cover vertical framing joints by applying tapes to heads and sills first, then to jambs. Cover horizontal framing joints by applying tapes to jambs, then to heads and sills.

D. Place joints in tapes at corners of opening with adjoining lengths butted together, not lapped. Seal joints in tapes with compatible sealant approved by tape manufacturer.

E. Center glass lites in openings on setting blocks, and press firmly against tape by inserting dense compression gaskets formed and installed to lock in place against faces of removable stops. Start gasket applications at corners and work toward centers of openings.

## 3.3 CLEANING AND PROTECTION

A. Immediately after installation, remove nonpermanent labels and clean surfaces.

B. Protect glass from contact with contaminating substances resulting from construction operations. Examine glass surfaces adjacent to or below exterior concrete and other masonry surfaces at frequent intervals during construction, but not less than once a month, for buildup of dirt, scum, alkaline deposits, or stains.

1. If, despite such protection, contaminating substances do contact with glass, remove substances immediately as recommended in writing by glass manufacturer. Remove and replace glass that cannot be cleaned without damage to coatings.

C. Remove and replace glass that is damaged during construction period.

## 3.4 MONOLITHIC GLASS SCHEDULE

A. Clear Glass Type: Fully tempered float glass.

1. Minimum Thickness: 6 mm.
2. Safety glazing required.

END OF SECTION 088000

SECTION 092216 - NON-STRUCTURAL METAL FRAMING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Framing systems.
2. Suspension systems.

1.2 ACTION SUBMITTALS

A. Product Data: For each product.

1.3 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of code-compliance certification for studs and tracks.

B. Evaluation reports for firestop tracks and power-actuated fasteners.

1.4 QUALITY ASSURANCE

A. Code-Compliance Certification of Studs and Tracks: Provide documentation that framing members are certified according to the product-certification program of the Certified Steel Stud Association.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For fire-resistance-rated assemblies that incorporate non-load-bearing steel framing, provide materials and construction identical to those tested in assembly indicated, in accordance with ASTM E119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated on Drawings, in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.

2.2 FRAMING SYSTEMS

A. Framing Members, General: Comply with ASTM C645 and AISI S220 for conditions indicated.

1. Steel Sheet Components: Comply with ASTM C645 and AISI S220 requirements for metal unless otherwise indicated

B. Studs and Track: AISI S220 and ASTM C645, Section 10.

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

a. CRACO Mfg., Inc.
b. ClarkDietrich.
c. MBA Building Supplies.
d. SCAFCO Steel Stud Company; Stone Group of Companies.

2. Minimum Base-Steel Thickness: As required by performance requirements for horizontal deflection.
3. Depth: As indicated on Drawings.

C. Slip-Type Head Joints: Where indicated, provide the following:
1. Double-Track System: Top outer tracks, inside track with 2-inch- (51-mm-) deep flanges in thickness not less than indicated for studs and fastened to studs, and outer track sized to friction-fit over inner track.
2. Deflection Track: Steel sheet top track manufactured to prevent cracking of finishes applied to interior partition framing resulting from deflection of structure above; in thickness not less than indicated for studs and in width to accommodate depth of studs.

a. Manufacturers: Subject to compliance with requirements, provide products by the following:
1) ClarkDietrich.
2) CRACO Mfg., Inc.

D. Firestop Tracks: Top track manufactured to allow partition heads to expand and contract with movement of structure while maintaining continuity of fire-resistance-rated assembly indicated; in thickness not less than indicated for studs and in width to accommodate depth of studs.

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

a. CEMCO; California Expanded Metal Products Co.
b. ClarkDietrich.
c. SCAFCO Steel Stud Company; Stone Group of Companies.

E. Flat Strap and Backing Plate: Steel sheet for blocking and bracing in length and width indicated.

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

a. CEMCO; California Expanded Metal Products Co.
b. ClarkDietrich.
c. MRI Steel Framing, LLC.
d. SCAFCO Steel Stud Company; Stone Group of Companies.

2. Minimum Base-Steel Thickness: As indicated on Drawings or 0.0329 inch (0.836 mm).

F. Hat-Shaped, Rigid Furring Channels:

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

a. CEMCO; California Expanded Metal Products Co.
b. ClarkDietrich.
c. SCAFCO Steel Stud Company; Stone Group of Companies.

2. Minimum Base-Steel Thickness: As indicated on Drawings.
3. Depth: As indicated on Drawings.

## 2.3 SUSPENSION SYSTEMS

A. Tie Wire: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.062-inch- (1.59-mm-) diameter wire, or double strand of 0.048-inch- (1.21-mm-) diameter wire.

B. Hanger Attachments to Concrete:

1. Post-Installed Anchors: Fastener systems with an evaluation report acceptable to authorities having jurisdiction, based on ICC-ES AC58 as appropriate for the substrate.

a. Uses: Securing hangers to structure.
b. Type: torque-controlled, adhesive anchor.
c. Material for Interior Locations: Carbon-steel components zinc-plated to comply with ASTM B633 or ASTM F1941 (ASTM F1941M), Class Fe/Zn 5, unless otherwise indicated.
d. Material for Exterior or Interior Locations and Where Stainless Steel Is Indicated: Alloy Group 1 (A1) stainless steel bolts, ASTM F593 (ASTM F738M), and nuts, ASTM F594 (ASTM F836M).

C. Wire Hangers: ASTM A641/A641M, Class 1 zinc coating, soft temper, 0.16 inch (4.12 mm) in diameter.

D. Flat Hangers: Steel sheet, in size indicated on Drawings or 1 by 3/16 inch (25 by 5 mm) by length indicated.

E. Carrying Channels (Main Runners): Cold-rolled, commercial-steel sheet with a base-steel thickness of 0.0538 inch (1.367 mm) and minimum 1/2-inch- (13-mm-) wide flanges.

1. Depth: As indicated on Drawings.

F. Furring Channels (Furring Members):

1. Hat-Shaped, Rigid Furring Channels: 7/8 inch (22 mm) deep.

a. Minimum Base-Steel Thickness: As indicated on Drawings.

2. Resilient Furring Channels: 1/2-inch- (13-mm-) deep members designed to reduce sound transmission.

   a. Configuration: Hat shaped.

## 2.4 AUXILIARY MATERIALS

A. General: Provide auxiliary materials that comply with referenced installation standards.

1. Fasteners for Steel Framing: Of type, material, size, corrosion resistance, holding power, and other properties required to fasten steel members to substrates.

# PART 3 - EXECUTION

## 3.1 INSTALLATION, GENERAL

A. Installation Standard: ASTM C754.
   1. Gypsum Board Assemblies: Also comply with requirements in ASTM C840 that apply to framing installation.

B. Install framing and accessories plumb, square, and true to line, with connections securely fastened.

C. Install supplementary framing, and blocking to support fixtures, equipment services, heavy trim, grab bars, toilet accessories, furnishings, or similar construction.

D. Install bracing at terminations in assemblies.

## 3.2 INSTALLATION OF FRAMING SYSTEMS

A. Install framing system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

B. Where studs are installed directly against exterior masonry walls or dissimilar metals at exterior walls, install isolation strip between studs and exterior wall.

C. Install studs so flanges within framing system point in same direction.

D. Install tracks at floors and overhead supports. Extend framing full height to structural supports or substrates above suspended ceilings except where partitions are indicated to terminate at suspended ceilings. Continue framing around ducts that penetrate partitions above ceiling.

   1. Slip-Type Head Joints: Where framing extends to overhead structural supports, install to produce joints at tops of framing systems that prevent axial loading of finished assemblies.
   2. Door Openings: Screw vertical studs at jambs to jamb anchor clips on door frames; install track section (for cripple studs) at head and secure to jamb studs.

a. Install two studds at each jamb unless otherwise indicated.

3. Fire-Resistance-Rated Partitions: Install framing to comply with fire-resistance-rated assembly indicated and support closures and to make partitions continuous from floor to underside of solid structure.

    a. Firestop Track: Where indicated, install to maintain continuity of fire-resistance-rated assembly indicated.

4. Sound-Rated Partitions: Install framing to comply with sound-rated assembly indicated.
5. Curved Partitions:

    a. Bend track to uniform curve and locate straight lengths so they are tangent to arcs.
    b. Begin and end each arc with a stud, and space intermediate studs equally along arcs. On straight lengths of no fewer than two studs at ends of arcs, place studs 6 inches (150 mm) o.c.

E. Z-Shaped Furring Members:

1. Erect insulation, specified in Section 072100 "Thermal Insulation," vertically and hold in place with Z-shaped furring members spaced 24 inches (610 mm) o.c.
2. Except at exterior corners, securely attach narrow flanges of furring members to wall with concrete stub nails, screws designed for masonry attachment, or powder-driven fasteners spaced 24 inches (610 mm) o.c.
3. At exterior corners, attach wide flange of furring members to wall with short flange extending beyond corner; on adjacent wall surface, screw-attach short flange of furring channel to web of attached channel. At interior corners, space second member no more than 12 inches (305 mm) from corner and cut insulation to fit.

F. Installation Tolerance: Install each framing member so fastening surfaces vary not more than 1/8 inch (3 mm) from the plane formed by faces of adjacent framing.

## 3.3 INSTALLATION OF SUSPENSION SYSTEMS

A. Install suspension system components according to spacings indicated, but not greater than spacings required by referenced installation standards for assembly types.

B. Isolate suspension systems from building structure where they abut or are penetrated by building structure to prevent transfer of loading imposed by structural movement.

C. Suspend hangers from building structure as follows:

1. Install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or suspension system.

    a. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.

2. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with locations of hangers required to support standard suspension

system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices.

a. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced installation standards.

3. Wire Hangers: Secure by looping and wire tying, either directly to structures or to inserts, eye screws, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause hangers to deteriorate or otherwise fail.
4. Flat Hangers: Secure to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices and fasteners that are secure and appropriate for structure and hanger, and in a manner that will not cause hangers to deteriorate or otherwise fail.
5. Do not attach hangers to steel roof deck.
6. Do not connect or suspend steel framing from ducts, pipes, or conduit.

D. Fire-Resistance-Rated Assemblies: Wire tie furring channels to supports.

## 3.4 FIELD QUALITY CONTROL

A. Installation Tolerances: Install suspension systems that are level to within 1/8 inch in 12 feet (3 mm in 3.6 m) measured lengthwise on each member that will receive finishes and transversely between parallel members that will receive finishes.

END OF SECTION 092216

SECTION 092900 - GYPSUM BOARD

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Interior gypsum board.
2. Tile backing panels.

1.2 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: Show locations and installation of control and expansion joints, including plans, elevations, sections, details of components, and attachments to other work.

C. Samples: For each texture finish indicated on same backing indicated for Work.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Resistance-Rated Assemblies: For fire-resistance-rated assemblies, provide materials and construction identical to those tested in assembly indicated in accordance with ASTM E119 by an independent testing agency.

B. STC-Rated Assemblies: For STC-rated assemblies, provide materials and construction identical to those tested in assembly indicated in accordance with ASTM E90 and classified in accordance with ASTM E413 by an independent testing agency.

2.2 GYPSUM BOARD, GENERAL

A. Size: Provide maximum lengths and widths available that will minimize joints in each area and that correspond with support system indicated.

2.3 INTERIOR GYPSUM BOARD

A. Gypsum Board, Type X: ASTM C1396/C1396M.

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

a. American Gypsum.
b. CertainTeed; SAINT-GOBAIN.
c. Georgia-Pacific Gypsum LLC.
d. Gold Bond Building Products, LLC provided by National Gypsum Company.
e. PABCO Gypsum.
f. USG Corporation.

2. Thickness: 5/8 inch (15.9 mm).
3. Long Edges: Tapered.

B. Gypsum Ceiling Board: ASTM C1396/C1396M.

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

a. American Gypsum.
b. CertainTeed; SAINT-GOBAIN.
c. Georgia-Pacific Gypsum LLC.
d. Gold Bond Building Products, LLC provided by National Gypsum Company.
e. PABCO Gypsum.
f. USG Corporation.

2. Thickness: 1/2 inch (12.7 mm).
3. Long Edges: Tapered.

## 2.4 TILE BACKING PANELS

A. Glass-Mat, Water-Resistant Backing Board: ASTM C1178/C1178M, with manufacturer's standard edges.

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

a. CertainTeed; SAINT-GOBAIN.
b. Georgia-Pacific Gypsum LLC.
c. Gold Bond Building Products, LLC provided by National Gypsum Company.
d. USG Corporation.

2. Core: As indicated on Drawings or 1/2 inch (12.7 mm), regular type.
3. Mold Resistance: ASTM D3273, score of 10 as rated in accordance with ASTM D3274.

## 2.5 TRIM ACCESSORIES

A. Interior Trim: ASTM C1047.

1. Material: Galvanized or aluminum-coated steel sheet or rolled zinc.
2. Shapes:

a. Cornerbead.
b. LC-Bead: J-shaped; exposed long flange receives joint compound.

c. L-Bead: L-shaped; exposed long flange receives joint compound.
d. U-Bead: J-shaped; exposed short flange does not receive joint compound.

## 2.6 JOINT TREATMENT MATERIALS

A. General: Comply with ASTM C475/C475M.

B. Joint Tape:

1. Interior Gypsum Board: Paper.
2. Tile Backing Panels: As recommended by panel manufacturer.

C. Joint Compound for Interior Gypsum Board: For each coat, use formulation that is compatible with other compounds applied on previous or for successive coats.

1. Prefilling: At open joints, rounded or beveled panel edges, and damaged surface areas, use setting-type taping compound.
2. Embedding and First Coat: For embedding tape and first coat on joints, fasteners, and trim flanges, use setting-type taping compound.

a. Use setting-type compound for installing paper-faced metal trim accessories.

3. Fill Coat: For second coat, use drying-type, all-purpose compound.
4. Finish Coat: For third coat, use drying-type, all-purpose compound.

D. Joint Compound for Tile Backing Panels:

1. Glass-Mat, Water-Resistant Backing Panel: As recommended by backing panel manufacturer.

## 2.7 AUXILIARY MATERIALS

A. Provide auxiliary materials that comply with referenced installation standards and manufacturer's written instructions.

B. Laminating Adhesive: Adhesive or joint compound recommended for directly adhering gypsum panels to continuous substrate.

C. Sound-Attenuation Blankets: ASTM C665, Type I (blankets without membrane facing) produced by combining thermosetting resins with mineral fibers manufactured from glass, slag wool, or rock wool.

1. Fire-Resistance-Rated Assemblies: Comply with mineral-fiber requirements of assembly.

D. Acoustical Sealant: As specified in Section 079219 "Acoustical Joint Sealants."

PART 3 - EXECUTION

3.1 INSTALLATION OF PANELS

A. Examine panels before installation. Reject panels that are wet, moisture damaged, and mold damaged.

B. Comply with ASTM C840.

C. Isolate perimeter of gypsum board applied to non-load-bearing partitions at structural abutments. Provide 1/4- to 1/2-inch- (6.4- to 12.7-mm-) wide spaces at these locations and trim edges with edge trim where edges of panels are exposed. Seal joints between edges and abutting structural surfaces with acoustical sealant.

D. For trim with back flanges intended for fasteners, attach to framing with same fasteners used for panels. Otherwise, attach trim according to manufacturer's written instructions.

3.2 FINISHING OF GYPSUM BOARD

A. Prefill open joints, rounded or beveled edges, and damaged surface areas.

B. Apply joint tape over gypsum board joints, except for trim products specifically indicated as not intended to receive tape.

C. Gypsum Board Finish Levels: Finish panels to levels indicated below and in accordance with ASTM C840:

1. Level 1: Ceiling plenum areas, concealed areas, and where indicated.
2. Level 2: Panels that are substrate for tile.
3. Level 3: Where indicated on Drawings.
4. Level 4: At panel surfaces that will be exposed to view unless otherwise indicated.
   a. Primer and its application to surfaces are specified in Section 099123 "Interior Painting."

D. Glass-Mat Faced Panels: Finish according to manufacturer's written instructions.

E. Surface Preparation and Primer: Prepare and apply primer to gypsum panels and other surfaces receiving texture finishes. Apply primer to surfaces that are clean, dry, and smooth.

3.3 PROTECTION

A. Protect installed products from damage from weather, condensation, direct sunlight, construction, and other causes during remainder of the construction period.

B. Remove and replace panels that are wet, moisture damaged, and mold damaged.

END OF SECTION 092900

SECTION 093013 - CERAMIC TILING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Ceramic mosaic tile.
2. Glazed wall tile.
3. Thresholds.
4. Tile backing panels.
5. Waterproof membranes.
6. Crack isolation membranes.
7. Setting material.
8. Grout materials.

1.2 ACTION SUBMITTALS

A. Product data.

B. Shop Drawings: Show locations, plans, and elevations, of each type of tile and tile pattern. Show widths, details, and locations of movement joints in tile substrates and finished tile surfaces. **Show thresholds.**

C. Samples:
1. Assembled samples mounted on a rigid panel, with grouted joints, for each type and composition of tile and for each color and finish required. Make samples at least **12 inches (300 mm) square** but not fewer than four tiles. Use grout of type and in color or colors approved for completed Work.
2. Full-size units of each type of trim and accessory **for each color and finish required**.
3. Stone thresholds in 6-inch (152-mm) lengths.

1.3 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

1.4 MAINTENANCE MATERIAL SUBMITTALS

A. Extra Stock Material: Furnish extra materials, from the same production run, to Owner that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Tile and Trim Units: **Furnish quantity of full-size units equal to 10 percent of amount installed for each type, composition, color, pattern, and size indicated.**

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Installer's supervisor for Project holds the International Masonry Institute's Supervisor Certification.
   2. Installer employs at least one installer for Project that has completed the Advanced Certification for Tile Installers (ACT) certification for installation of mud floors, mud walls, membranes, shower receptors and large format tile.

# PART 2 - PRODUCTS

## 2.1 PRODUCTS, GENERAL

A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.

B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.

## 2.2 CERAMIC MOSAIC TILE

A. Ceramic Mosaic Tile Type: **Glazed, Chemical resistant - CT-X**.

   1. Certification: Porcelain tile certified by the Porcelain Tile Certification Agency.
   2. Module Size: **2 by 2 inches (50.8 by 50.8 mm)**].
   3. Thickness: 1/4 inch (6.4 mm).
   4. Face: **Pattern of design indicated,** with cushion edges.
   5. Surface: **Smooth, without** and **Slip resistant, with** abrasive admixture.
   6. Product Use Classification: **Interior, Wet Plus (IW+)**
   7. Physical Properties: Chemical resistant when tested with indicated chemicals in accordance with ASTM C650.

   8. Tile Color and Pattern: **As selected by Architect from manufacturer's full range**
   9. Grout Color: **As selected by Architect from manufacturer's full range**.
   10. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable **and matching characteristics of adjoining flat tile**. Provide shapes as follows, selected from manufacturer's standard shapes:
      a. As Indicated in Room Finish Legend.
      b. Internal Corners: Field-butted square corners. For coved base and cap, use angle pieces designed to fit with stretcher shapes.
      c. Tapered Transition Tile: Shape designed to effect transition between thickness of tile floor and adjoining floor finishes of different thickness, tapered to provide reduction in thickness from 1/2 to 1/4 inch (12.7 to 6.4 mm) across nominal 4-inch (102-mm) dimension.

2.3 GLAZED WALL TILE

A. Glazed Wall Tile Type – CT-X:

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

   a. American Olean; a brand of Dal-Tile Corporation.
   b. Daltile; a brand of Dal-Tile Corporation.
   c. Interceramic.

2. Module Size: As Indicated in Drawings.
3. Face Size Variation: Rectified.
4. Thickness: 5/16 inch (8 mm).
5. Tile Color and Pattern: **As selected by Architect from manufacturer's full range**
6. Grout Color: **As selected by Architect from manufacturer's full range**

7. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable **and matching characteristics of adjoining flat tile**. Provide shapes as follows, selected from manufacturer's standard shapes:

   a. Base: Straight, module size: **As Indicated in Drawings.**
   b. Wainscot Cap, Surface bullnose, module size: **As Indicated in Drawings**
   c. External Corners: Surface bullnose; same size as adjoining flat tile.
   d. Internal Corners: Field-butted square corners. For coved base and cap, use angle pieces designed to fit with stretcher shapes.

B. Accessories: Provide vitreous china accessories of type and size indicated; suitable for installing by same method as used for adjoining wall tile.

1. One soap holder for each shower and tub indicated.
2. One paper holder at each water closet.
3. Color and Finish: **As selected by Architect from manufacturer's full range.**

2.4 THRESHOLDS

A. General: Fabricate to sizes and profiles indicated or required to provide transition between adjacent floor finishes.

1. Bevel edges at 1:2 slope, with lower edge of bevel aligned with or up to 1/16 inch (1.5 mm) above adjacent floor surface. Finish bevel to match top surface of threshold. Limit height of threshold to 1/2 inch (12.7 mm) or less above adjacent floor surface.

B. Marble Thresholds: ASTM C503/C503M, with a minimum abrasion resistance of [**10**] [**12**] in accordance with ASTM C1353/C1353M or ASTM C241/C241M and with honed finish.

1. Description:

   a. Uniform, fine- to medium-grained white stone with gray veining.

## 2.5 TILE BACKING PANELS

A. Coated Glass-Mat, Water-Resistant Gypsum Backing Panel: ASTM C1178/C1178M, with a water-resistant coating on one surface, and manufacturer's standard edges.

1. Manufacturers: Subject to compliance with requirements, [**provide products by the following**] [**provide products by one of the following**] [**available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following**]:

   a. CertainTeed; SAINT-GOBAIN.
   b. Georgia-Pacific Gypsum LLC.
   c. USG Corporation.

2. Core: **5/8 inch (15.9 mm), Type X**.
3. Mold Resistance: ASTM D3273, score of 10 as rated in accordance with ASTM D3274.

## 2.6 WATERPROOF MEMBRANES

A. General: Manufacturer's standard product that complies with ANSI A118.10 and ANSI A118.12 and is recommended by manufacturer for application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Waterproof Membrane, Fluid Applied: Liquid-latex rubber or elastomeric polymer with continuous fabric reinforcement.

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

   a. ARDEX Americas.
   b. H.B. Fuller Construction Products Inc. / TEC.
   c. MAPEI Corporation.
   d. Sika Corporation.
   e. Southern Grouts & Mortars, Inc.

## 2.7 CRACK ISOLATION MEMBRANES

A. General: Manufacturer's standard product, selected from the following, that complies with ANSI A118.12 for standard performance and is recommended by manufacturer for application indicated. Include reinforcement and accessories recommended by manufacturer.

B. Crack Isolation Membrane, Fluid Applied: Liquid-latex rubber or elastomeric polymer.

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

   a. H.B. Fuller Construction Products Inc. / TEC.
   b. MAPEI Corporation.
   c. Sika Corporation.

d. Southern Grouts & Mortars, Inc.

2.8 SETTING MATERIALS

A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.

1. Cleavage Membrane: Installer's option of material that complies with ANSI A108.02, paragraph 3.8.

B. Water-Cleanable, Tile-Setting Epoxy: ANSI A118.3.

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

a. ARDEX Americas.
b. Atlas Minerals & Chemicals, Inc.
c. MAPEI Corporation.
d. Southern Grouts & Mortars, Inc.

2. Provide product capable of withstanding continuous and intermittent exposure to temperatures of up to 140 and 212 deg F (60 and 100 deg C), respectively, and certified by manufacturer for intended use.

C. Chemical-Resistant Furan Mortar: ANSI A118.5, with carbon filler.

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

a. Atlas Minerals & Chemicals, Inc.
b. Sauereisen.
c. Summitville Tiles, Inc.

2.9 GROUT MATERIALS

A. Sand-Portland Cement Grout: ANSI A108.10, consisting of white or gray cement and white or colored aggregate as required to produce color indicated.

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

a. ARDEX Americas.
b. H.B. Fuller Construction Products Inc. / TEC.
c. Laticrete International, Inc.
d. MAPEI Corporation.
e. Sakrete; CRH Americas, Oldcastle APG.
f. Southern Grouts & Mortars, Inc.

B. High-Performance Tile Grout: ANSI A118.7.

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

    a. ARDEX Americas.
    b. H.B. Fuller Construction Products Inc. / TEC.
    c. MAPEI Corporation.
    d. Southern Grouts & Mortars, Inc.

2.10 MISCELLANEOUS MATERIALS

A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting and adhesive materials for installations indicated.

B. Vapor-Retarder Membrane: Polyethylene sheeting, ASTM D4397, 4.0 mils (0.1 mm) thick.

C. Retain surfaces of tile against adherence of mortar and grout; compatible with tile, mortar, and grout products and easily removable after grouting is completed without damaging grout or tile.

D. Tile Cleaner: A neutral cleaner capable of removing soil and residue without harming tile and grout surfaces, specifically approved for materials and installations indicated by tile and grout manufacturers.

E. Grout Sealer: Grout manufacturer's standard product for sealing grout joints that does not change color or appearance of grout.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

    1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
    2. Verify that concrete substrates for tile floors installed with adhesives bonded mortar bed or thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.

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

3.2 PREPARATION

A. Remove coatings, including curing compounds or other coatings, that are incompatible with tile-setting materials.

B. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with adhesives or thinset mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.

C. Where indicated, prepare substrates to receive waterproof membrane by applying a reinforced mortar bed that complies with ANSI A108.1 and is sloped 1/4 inch per foot (1:50) toward drains.

D. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

E. Substrate Flatness:

1. For tile shorter than 15 inches (381 mm), confirm that structure or substrate is limited to variation of 1/4 inch in 10 ft. (6.4 mm in 3 m) from the required plane, and no more than 1/16 inch in 12 inches (1.5 mm in 300 mm) when measured from tile surface high points.
2. For large format tile, tile with at least one edge 15 inches (381 mm) or longer, confirm that structure or substrate is limited to 1/8 inch in 10 ft. (3 mm in 3 m) from the required plane, and no more than 1/16 inch in 24 inches (1.5 mm in 609 mm) when measured from tile surface high points.

## 3.3 INSTALLATION OF CERAMIC TILE SYSTEM

A. Install tile backing panels and treat joints in accordance with ANSI A108.11 and manufacturer's written instructions for type of application indicated.

B. Install waterproof membrane to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness that is bonded securely to substrate.

1. Allow waterproof membrane to cure and verify by testing that it is watertight before installing tile or setting materials over it.

C. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.

1. Allow crack isolation membrane to cure before installing tile or setting materials over it.

D. Install tile in accordance with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of ANSI A108 series that are referenced in TCNA installation methods and specified in tile installation schedules, and apply to types of setting and grouting materials used.

E. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.

F. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.

G. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.

H. Where accent tile differs in thickness from field tile, vary setting-bed thickness so that tiles are flush.

I. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.

J. Lay out tile wainscots to dimensions indicated or to next full tile beyond dimensions indicated.

K. Movement Joints: Provide movement joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated on Drawings. Form joints during installation of setting materials, mortar beds, and tile. Keep joints free of dirt, debris, and setting materials prior to filling with sealants. Do not saw-cut joints after installing tiles.

1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.

L. Thresholds: Install thresholds in same type of setting bed as adjacent floor unless otherwise indicated.

## 3.4 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE

A. Interior Wall Installations, Masonry or Concrete:

1. TCNA W202I: Thinset mortar over waterproof membrane.

a. Ceramic Tile Type: As Indicated on Drawings
b. Thinset Mortar: Improved modified dry-set mortar.
c. Grout: High-performance unsanded cement grout.
d. Waterproof Membrane: As recommended by setting material manufacturer.
e. Joint Width: 1/8 inch (3.2 mm).
f. Movement Joints: Types located on Drawings.

B. Interior Wall Installations, Metal Studs or Furring:

1. TCNA W242: Organic adhesive on gypsum board.

a. Ceramic Tile Type: As Indicated on Drawings.
b. Grout: High-performance unsanded cement grout.
c. Joint Width: 1/8 inch (3.2 mm).
d. Movement Joints: Types located on Drawings.

C. Bathtub/Shower Wall Installations:

1. TCNA B419 Thinset mortar over waterproof membrane on coated glass-mat, water-resistant gypsum backer board.

    a. Ceramic Tile Type: As Indicated on Drawings.
    b. Thinset Mortar: Modified dry-set or Improved modified dry-set mortar.
    c. Grout: High-performance unsanded cement grout.
    d. Waterproof Membrane: As recommended by setting material manufacturer.
    e. Joint Width: 1/8 inch (3.2 mm).
    f. Movement Joints: Types located on Drawings.

D. Interior Floor Installations, Concrete:

1. TCNA F115: Thinset mortar over crack isolation membrane.

    a. Chemical-Resistant Tile Type: As Indicated in Drawings. .
    b. Thinset Mortar: Improved modified dry-set mortar.
    c. Grout: Chemical-resistant furan.
    d. Crack Isolation Membrane: Fabric-reinforced, fluid-applied membrane.
    e. Joint Width: 1/8 inch (3.2 mm).
    f. Movement Joints: Types located on Drawings.

END OF SECTION 093013

SECTION 095123 - ACOUSTICAL TILE CEILINGS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Acoustical tiles.
2. Metal suspension system.
3. Accessories.
4. Metal edge moldings and trim.

B. Related Requirements:

1. None

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and texture specified.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, and coordinated with each other, using input from installers of the items involved.

B. Product test reports.

C. Research reports.

D. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Maintenance data.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: Class A in accordance with ASTM E1264.

2.2 ACOUSTICAL TILES

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

1. Basis of Design: Armstrong World Industries.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Acoustical Tile Standard: Manufacturer's standard tiles of configuration indicated that comply with ASTM E1264.

C. Classification: Type ACT-1
1. Model: Ultima Health Zone AirAssure, 15/16” Square-Layin; #1950
2. Size: 24” x 24” x 3/4"
3. Color: White.
4. Light Reflectance (LR): 86%
5. Ceiling Attenuation Class (CAC): 40
6. Noise Reduction Coefficient (NRC): 0.70
7. Edge/Joint Detail: As indicated by manufacturer's designation.
8. Thickness: 3/4 inch (19 mm).
9. Fire Performance: Class A
10. Modular Size: As indicated on Drawings.
11. Warranty: 30-year

D. Classification: Type ACT-2
1. Model: Clean Room VL, 15/16”, Square Lay-in; #868
2. Size: 24” x 24” x 5/8"
3. Color: White.
4. Light Reflectance (LR): 80%
5. Ceiling Attenuation Class (CAC): 40
6. Noise Reduction Coefficient (NRC): N/A
7. Edge/Joint Detail: As indicated by manufacturer's designation.
8. Thickness: 5/8 inch (19 mm).
9. Fire Performance: Class A
10. Mold / Mildew Resistance: Bioblock
11. Modular Size: As indicated on Drawings.
12. Warranty: 10-year

2.3 METAL SUSPENSION SYSTEM

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

1. Armstrong Ceiling & Wall Solutions.
2. CertainTeed; SAINT-GOBAIN.
3. USG Corporation.

B. Metal Suspension-System Standard: Manufacturer's standard, direct-hung, fully concealed, metal suspension system that complies with applicable requirements in ASTM C635/C635M.

C. Direct-Hung, Double-Web Suspension System: Main and cross runners roll formed from and capped with cold-rolled steel sheet, prepainted, electrolytically zinc coated, or hot-dip galvanized, G30 (Z90) coating designation.

D. Warranty: 30-year limited warranty when used with HumiGuard Plus products, unless noted otherwise.

E. Access: Upward and, with initial access openings of size indicated below and located throughout ceiling within each module formed by main and cross runners, with additional access available by progressively removing remaining acoustical tiles.
1. Initial Access Opening: In each module, 24 by 24 inches (610 by 610 mm).

2.4 METAL SUSPENSION SYSTEM - TYPE: ACT-1:
1. Classification: AL Prelude XL, Exposed Tee
2. Face Profile: 15/16”
3. Description: 2’ Main Beam with Cross Tee
4. Dimensions: 24” x 15/16” x 1 11/16””
5. Structural Classification: Heavy-duty system.

2.5 METAL SUSPENSION SYSTEM - TYPE: ACT-2
1. Classification: Clean Room, Exposed Tee; Gasketed
2. Face Profile: 15/16”
3. Description: 2’ Main Beam with Cross Tee
4. Dimensions: 24” x 15/16” x 1 11/16””
5. Structural Classification: Heavy-duty system.
6. Hold-Down Clip system

2.6 ACCESSORIES

A. Hold-Down Clips: Manufacturer's standard hold-down clips designed to secure acoustic tiles in-place to reduce air leakage.
1. Products:
a. Clear Room Hold-Down Clip (CHDC) – attaches to top bulb of suspension system
b. Border Hold-Down Clip (BHDC) – attaches to angle molding at perimeter

## 2.7 METAL EDGE MOLDINGS AND TRIM

A. Roll-Formed, Sheet-Metal Edge Moldings and Trim: Type and profile indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations complying with seismic design requirements; formed from sheet metal of same material, finish, and color as that used for of suspension-system runners.

B. Angle Molding: Manufacturer’s standard perimeter edge angle molding.
   1. Size: 7/8” Hemmed or similar
   2. Color: White

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Measure each ceiling area and establish layout of acoustical tiles to balance border widths at opposite edges of each ceiling. Avoid using less-than-half-width tiles at borders unless otherwise indicated.

B. Layout openings for penetrations centered on the penetrating items.

## 3.2 INSTALLATION OF SUSPENDED ACOUSTICAL TILE CEILINGS

A. Install suspended acoustical tile ceilings in accordance with ASTM C636/C636M and manufacturer's written instructions.

B. Install edge moldings and trim of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical tiles.

   1. Apply acoustical sealant in a continuous ribbon concealed on back of vertical legs of moldings before they are installed.
   2. Do not use exposed fasteners, including pop rivets, on moldings and trim.

## 3.3 FIELD QUALITY CONTROL

A. Special Inspections: Owner to engage a qualified special inspector to perform inspections:

   1. Periodic inspection during the installation of suspended ceiling grids in accordance with ASCE/SEI 7.

END OF SECTION 095123

SECTION 096513 - RESILIENT BASE AND ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Vinyl Base

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Sustainable Design Submittals:

C. Samples: For each exposed product and for each color and texture specified.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. None

2.2 VINYL BASE

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

1. Flexco Corporation.
2. Mannington Mills, Inc.
3. Roppe Corporation; Roppe Holding Company.
4. Shaw Industries Group, Inc.; Berkshire Hathaway Company.
5. Tarkett USA.

B. Product Standard: ASTM F1861, Type TV (vinyl, thermoplastic).

1. Group: I (solid, homogeneous) or II (layered).
2. Style and Location:
   a. Style A, Cove: Provide in areas with resilient floor coverings.

C. Minimum Thickness: 0.125 inch (3.2 mm).

D. Height: As indicated on Drawings.

E. Lengths: Coils in manufacturer's standard length.

F. Outside Corners: Preformed.

G. Inside Corners: Preformed.

H. Colors and Patterns: As indicated by manufacturer's designations.

## 2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by resilient-product manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by resilient-product manufacturer for resilient products and substrate conditions indicated.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Prepare substrates according to manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates for Resilient Stair Accessories: Prepare horizontal surfaces according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 10 pH.
4. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
   a. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient products until materials are the same temperature as space where they are to be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient products.

## 3.2 RESILIENT BASE INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient base.

B. Apply resilient base to walls, columns, pilasters, casework and cabinets in toe spaces, and other permanent fixtures in rooms and areas where base is required.

C. Install resilient base in lengths as long as practical without gaps at seams and with tops of adjacent pieces aligned.

D. Tightly adhere resilient base to substrate throughout length of each piece, with base in continuous contact with horizontal and vertical substrates.

E. Do not stretch resilient base during installation.

F. On masonry surfaces or other similar irregular substrates, fill voids along top edge of resilient base with manufacturer's recommended adhesive filler material.

G. Preformed Corners: Install preformed corners before installing straight pieces.

H. Job-Formed Corners:

1. Inside Corners: Use straight pieces of maximum lengths possible and form with returns not less than 3 inches (76 mm) in length.

a. Miter or cope corners to minimize open joints.

## 3.3 RESILIENT ACCESSORY INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient accessories.

## 3.4 CLEANING AND PROTECTION

A. Comply with manufacturer's written instructions for cleaning and protecting resilient products.

B. Cover resilient products subject to wear and foot traffic until Substantial Completion.

END OF SECTION 096513

SECTION 096516 - RESILIENT SHEET FLOORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Vinyl sheet flooring with backing.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color, texture, and pattern specified.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are competent in techniques required by manufacturer for resilient sheet flooring installation and seaming method indicated.

   1. Engage an installer who employs workers for this Project who are trained or certified by resilient sheet flooring manufacturer for installation techniques required.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient sheet flooring, as determined by testing identical products according to ASTM E648 or NFPA 253 by a qualified testing agency.

   1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

2.2 VINYL SHEET FLOORING WITH BACKING

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

   1. Altro.

2. Armstrong Flooring, Inc.
3. Forbo Flooring Systems.
4. IVC Commercial; IVC Group.
5. Mannington Mills, Inc.
6. Shaw Industries Group, Inc.; Berkshire Hathaway Company.

B. Product Standard: ASTM F1303.

1. Type (Binder Content): Type I, minimum binder content of 90 percent.
2. Wear-Layer Thickness: Grade 1.
3. Overall Thickness: As standard with manufacturer.
4. Interlayer Material: Foamed plastic.
5. Backing Class: Class B (nonfoamed plastic).

C. Wearing Surface: Smooth.

D. Sheet Width: As standard with manufacturer.

E. Seamless-Installation Method: **Heat welded**.

F. Colors and Patterns: **As indicated by manufacturer's designations**.

## 2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by resilient sheet flooring manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by flooring and adhesive manufacturers to suit resilient sheet flooring and substrate conditions indicated.

C. Seamless-Installation Accessories:

1. Heat-Welding Bead: Manufacturer's solid-strand product for heat welding seams.

   a. Colors: Match flooring.

2. Chemical-Bonding Compound: Manufacturer's product for chemically bonding seams.

D. Integral-Flash-Cove-Base Accessories:

1. Cove Strip: 1-inch (25-mm) radius provided or approved by resilient sheet flooring manufacturer.
2. Cap Strip: Tapered vinyl cap provided or approved by resilient sheet flooring manufacturer.
3. Corners: Metal inside and outside corners and end stops provided or approved by resilient sheet flooring manufacturer.

E. Floor Polish: Provide protective, liquid floor-polish products recommended by resilient sheet flooring manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Prepare substrates according to resilient sheet flooring manufacturer's written instructions to ensure adhesion of resilient sheet flooring.

B. Concrete Substrates: Prepare according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by resilient sheet flooring manufacturer. Do not use solvents.
3. Alkalinity and Adhesion Testing: Perform tests recommended by resilient sheet flooring manufacturer. Proceed with installation only after substrate alkalinity falls within range on pH scale recommended by manufacturer in writing, but not less than 5 or more than 10 pH.
4. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
   a. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install resilient sheet flooring until materials are the same temperature as space where they are to be installed.

1. At least 48 hours in advance of installation, move flooring and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient sheet flooring.

3.2 RESILIENT SHEET FLOORING INSTALLATION

A. Comply with manufacturer's written instructions for installing resilient sheet flooring.

B. Unroll resilient sheet flooring and allow it to stabilize before cutting and fitting.

C. Lay out resilient sheet flooring as follows:

1. Maintain uniformity of flooring direction.
2. Minimize number of seams; place seams in inconspicuous and low-traffic areas, at least 6 inches (152 mm) away from parallel joints in flooring substrates.
3. Match edges of flooring for color shading at seams.
4. Avoid cross seams.

D. Scribe and cut resilient sheet flooring to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend resilient sheet flooring into toe spaces, door reveals, closets, and similar openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on resilient sheet flooring as marked on substrates. Use chalk or other nonpermanent marking device.

G. Adhere resilient sheet flooring to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

H. Seamless Installation:

1. Heat-Welded Seams: Comply with ASTM F1516. Rout joints and heat weld with welding bead to fuse sections permanently into a seamless flooring installation. Prepare, weld, and finish seams to produce surfaces flush with adjoining flooring surfaces.
2. Chemically Bonded Seams: Bond seams with chemical-bonding compound to fuse sections permanently into a seamless flooring installation. Prepare seams and apply compound to produce tightly fitted seams without gaps, overlays, or excess bonding compound on flooring surfaces.

I. Integral-Flash-Cove Base: Cove resilient sheet flooring 6 inches (152 mm) up vertical surfaces. Support flooring at horizontal and vertical junction with cove strip. Butt at top against cap strip.

1. Install metal corners at inside and outside corners.

J. Floor Polish: Remove soil, adhesive, and blemishes from flooring surfaces before applying liquid floor polish.

1. Apply two coat(s).

END OF SECTION 096516

SECTION 096519 - RESILIENT TILE FLOORING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid vinyl floor tile.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each exposed product and for each color and pattern specified.

1.3 CLOSEOUT SUBMITTALS

A. Maintenance data.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: An entity that employs installers and supervisors who are competent in techniques required by manufacturer for floor tile installation.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Fire-Test-Response Characteristics: For resilient floor tile, as determined by testing identical products according to ASTM E648 or NFPA 253 by a qualified testing agency.

1. Critical Radiant Flux Classification: Class I, not less than 0.45 W/sq. cm.

2.2 SOLID VINYL FLOOR TILE

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

1. Altro.
2. Armstrong Flooring, Inc.
3. Congoleum Flooring.
4. Flexco Corporation.
5. IVC Commercial; IVC Group.
6. Mannington Mills, Inc.

B. Tile Standard: ASTM F1700.

1. Class: As indicated by product designations.
2. Type: B, Embossed Surface.

C. Size: 3 by 36 inches (76 by 914 mm).

D. Colors and Patterns: As indicated by manufacturer's designations.

## 2.3 INSTALLATION MATERIALS

A. Trowelable Leveling and Patching Compounds: Latex-modified, portland-cement-based or blended hydraulic-cement-based formulation provided or approved by floor tile manufacturer for applications indicated.

B. Adhesives: Water-resistant type recommended by floor tile and adhesive manufacturers to suit floor tile and substrate conditions indicated.

C. Floor Polish: Provide protective, liquid floor-polish products recommended by floor tile manufacturer.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Prepare substrates according to floor tile manufacturer's written instructions to ensure adhesion of resilient products.

B. Concrete Substrates: Prepare according to ASTM F710.

1. Verify that substrates are dry and free of curing compounds, sealers, and hardeners.
2. Remove substrate coatings and other substances that are incompatible with adhesives and that contain soap, wax, oil, or silicone, using mechanical methods recommended by floor tile manufacturer. Do not use solvents.
3. Moisture Testing: Perform tests so that each test area does not exceed 200 sq. ft. (18.6 sq. m), and perform no fewer than three tests in each installation area and with test areas evenly spaced in installation areas.
   a. Relative Humidity Test: Using in-situ probes, ASTM F2170. Proceed with installation only after substrates have a maximum 75 percent relative humidity level measurement.

C. Fill cracks, holes, and depressions in substrates with trowelable leveling and patching compound; remove bumps and ridges to produce a uniform and smooth substrate.

D. Do not install floor tiles until materials are the same temperature as space where they are to be installed.

1. At least 48 hours in advance of installation, move resilient floor tile and installation materials into spaces where they will be installed.

E. Immediately before installation, sweep and vacuum clean substrates to be covered by resilient floor tile.

## 3.2 FLOOR TILE INSTALLATION

A. Comply with manufacturer's written instructions for installing floor tile.

B. Lay out floor tiles from center marks established with principal walls, discounting minor offsets, so tiles at opposite edges of room are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half tile at perimeter.

1. Lay tiles square with room axis.

C. Match floor tiles for color and pattern by selecting tiles from cartons in the same sequence as manufactured and packaged, if so numbered. Discard broken, cracked, chipped, or deformed tiles.

1. Lay tiles in pattern of colors and sizes indicated.

D. Scribe, cut, and fit floor tiles to butt neatly and tightly to vertical surfaces and permanent fixtures including built-in furniture, cabinets, pipes, outlets, and door frames.

E. Extend floor tiles into toe spaces, door reveals, closets, and similar openings. Extend floor tiles to center of door openings.

F. Maintain reference markers, holes, and openings that are in place or marked for future cutting by repeating on floor tiles as marked on substrates. Use chalk or other nonpermanent marking device.

G. Adhere floor tiles to substrates using a full spread of adhesive applied to substrate to produce a completed installation without open cracks, voids, raising and puckering at joints, telegraphing of adhesive spreader marks, and other surface imperfections.

H. Floor Polish: Remove soil, adhesive, and blemishes from floor tile surfaces before applying liquid floor polish.

1. Apply finish coat(s) per manufacture’s recommendation.

END OF SECTION 096519

SECTION 099113 - EXTERIOR PAINTING

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. Primers.
2. Finish coatings.
3. Floor sealers and paints.

B. Related Requirements:
1. All materials shall meet the Buy American Build American Act 2021.

1.3 ACTION SUBMITTALS

A. Qualification Data: For Installer, including list of ABAA-certified installers and supervisors employed by Installer, who work on Project

B. Product Data: For each type of product.

1. Include preparation requirements and application instructions.
2. Indicate VOC content.

C. Samples: For each type of topcoat product.

D. Samples for Initial Selection: For each type of topcoat product.

E. Samples for Verification: For each type of paint system and each color and gloss of topcoat.

1. Submit Samples on rigid backing, 8 inches (200 mm) square.
2. Apply coats on Samples in steps to show each coat required for system.
3. Label each coat of each Sample.
4. Label each Sample for location and application area.

F. Product Schedule: Use same designations indicated on Drawings and in the Finish Schedule to cross-reference paint systems specified in this Section. Include color designations. Product and Color selection by Owner where information is not provided in Finish Schedule.

## 1.4 MAINTENANCE MATERIAL SUBMITTALS

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

## 1.5 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify selections made under Sample submittals, to demonstrate aesthetic effects, and to set quality standards for materials and execution.

1. Architect will select one surface to represent surfaces and conditions for application of each paint system.

    a. Vertical and Horizontal Surfaces: Provide samples of at least 100 sq. ft. (9 sq. m).
    b. Other Items: Architect will designate items or areas required.

2. Final approval of color selections will be based on mockups.

    a. If preliminary color selections are not approved, apply additional mockups of additional colors selected by Architect at no added cost to Owner.

3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Store materials not in use in tightly covered containers in well-ventilated areas with ambient temperatures continuously maintained at not less than 45 deg F (7 deg C).

1. Maintain containers in clean condition, free of foreign materials and residue.
2. Remove rags and waste from storage areas daily.

## 1.7 FIELD CONDITIONS

A. Apply paints only when temperature of surfaces to be painted and ambient air temperatures are between 50 and 95 deg F (10 and 35 deg C).

B. Do not apply paints in snow, rain, fog, or mist; when relative humidity exceeds 85 percent; at temperatures less than 5 deg F (3 deg C) above the dew point; or to damp or wet surfaces.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

A. Basis of Design: Sherwin Williams

B. Source Limitations: Obtain each paint product from single source from single manufacturer.

### 2.2 PAINT PRODUCTS, GENERAL

A. Material Compatibility:

1. Provide materials for use within each paint system that are compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer based on testing and field experience.
2. For each coat in a paint system, provide products recommended in writing by topcoat manufacturer for use in paint system and on substrate indicated.

B. Colors: As selected and listed in Finish Schedule and by Owner from manufacturer's full range

### 2.3 PRIMERS

A. Surface-Tolerant Metal Primer: Corrosion-resistant, solvent-based metal primer formulated for use on structural steel and metal fabrications that have been minimally prepared.
1. Basis of Design: Sherwin Williams

B. Water-Based Bonding Primer: Pigmented, water-based-emulsion primer formulated for exterior use and to promote adhesion of subsequent specified coatings.

1. Basis of Design: Sherwin Williams

### 2.4 FINISH COATINGS

A. Exterior Latex Paint, Flat: Water-based, pigmented coating; formulated for alkali, mold, microbial, and water resistance and for use on exterior surfaces, such as portland cement plaster, concrete, and primed wood.

1. Basis of Design: Sherwin Williams

B. Exterior Latex Paint, Low Sheen: Water-based, pigmented coating; formulated for alkali, mold, microbial, and water resistance and for use on exterior surfaces, such as portland cement plaster, concrete, and primed wood.

1. Basis of Design: Sherwin Williams

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for maximum moisture content and other conditions affecting performance of the Work.

B. Maximum Moisture Content of Substrates: When measured with an electronic moisture meter as follows:

1. Concrete: 12 percent.
2. Fiber-Cement Board: 12 percent.
3. Masonry (Clay and Concrete Masonry Units): 12 percent.
4. Wood: 15 percent.
5. Gypsum Board: 12 percent.

C. Verify suitability of substrates, including surface conditions and compatibility, with finishes and primers.

D. Proceed with coating application only after unsatisfactory conditions have been corrected.

1. Application of coating indicates acceptance of surfaces and conditions.

### 3.2 PREPARATION

A. Comply with manufacturer's written instructions applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

1. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection.

C. Clean substrates of substances that could impair bond of paints, including dust, dirt, oil, grease, and incompatible paints and encapsulants.

1. Remove incompatible primers and reprime substrate with compatible primers or apply tie coat as required to produce paint systems specified in this Section.

D. Primed Steel Substrates: Clean field welds, bolted connections, and areas where shop paint is abraded. Paint exposed areas with the same material as used for shop priming to comply with SSPC-PA 1 for touching up shop-primed surfaces.

E. Galvanized-Metal Substrates: Remove grease and oil residue from galvanized sheet metal by mechanical methods to produce clean, lightly etched surfaces that promote adhesion of subsequently applied paints.

F. Aluminum Substrates: Remove loose surface oxidation.

G. Wood Substrates:

1. Scrape and clean knots. Before applying primer, apply coat of knot sealer recommended in writing by topcoat manufacturer for exterior use in paint system indicated.
2. Sand surfaces that will be exposed to view and remove sanding dust.
3. Prime edges, ends, faces, undersides, and backsides of wood.
4. After priming, fill holes and imperfections in the finish surfaces with putty or plastic wood filler. Sand smooth when dried.

## 3.3 INSTALLATION

A. Apply paints in accordance with manufacturer's written instructions.

1. Use applicators and techniques suited for paint and substrate indicated.
2. Paint surfaces behind movable items same as similar exposed surfaces. Before final installation, paint surfaces behind permanently fixed items with prime coat only.
3. Paint both sides and edges of exterior doors and entire exposed surface of exterior door frames.
4. Do not paint over labels of independent testing agencies or equipment name, identification, performance rating, or nomenclature plates.
5. Primers specified in the Exterior Painting Schedule may be omitted on items that are factory primed or factory finished if compatible with intermediate and topcoat coatings and acceptable to intermediate and topcoat paint manufacturers.

B. Tint undercoats same color as topcoat but tint each undercoat a lighter shade to facilitate identification of each coat if multiple coats of same material are to be applied. Provide sufficient difference in shade of undercoats to distinguish each separate coat.

C. If undercoats or other conditions show through topcoat, apply additional coats until cured film has a uniform paint finish, color, and appearance.

D. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

E. Painting Fire Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

1. Paint the following work where exposed to view:
   a. Uninsulated metal piping.
   b. Uninsulated plastic piping.
   c. Pipe hangers and supports.
   d. Uninsulated metal HVAC ducts
   e. HVAC duct support brackets and fasteners.
   f. Metal gutters and downspouts
   g. Metal conduit.
   h. Plastic conduit.

## 3.4 FIELD QUALITY CONTROL

A. Dry Film Thickness Testing: Owner may engage the services of a qualified testing and inspecting agency to inspect and test paint for dry film thickness.

1. Contractor shall touch up and restore painted surfaces damaged by testing.
2. If test results show that dry film thickness of applied paint does not comply with paint manufacturer's written instructions, Contractor shall pay for testing and apply additional coats as needed to provide dry film thickness that complies with paint manufacturer's written instructions.

## 3.5 CLEANING AND PROTECTION

A. At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

1. Do not clean equipment with free-draining water and prevent solvents, thinners, cleaners, and other contaminants from entering into waterways, sanitary and storm drain systems, and ground.
2. Dispose of contaminants in accordance with requirements of authorities having jurisdiction.
3. Allow empty paint cans to dry before disposal.

B. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

C. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in undamaged condition.

D. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

## 3.6 EXTERIOR PAINTING SCHEDULE, CONCRETE SUBSTRATES

A. Exterior, Alkali-Resistant, Water-Based Primer: Pigmented, water-based primer formulated for use on alkaline surfaces, such as exterior plaster, vertical concrete, and masonry.
1. Manufacturer: Sherwin Williams
2. Product: LOXCON Concrete & Masonry Primer/Sealer
3. Sheen: Flat
4. Product No.: LX02W0050

## 3.7 EXTERIOR PAINTING SCHEDULE, MASONRY SUBSTRATES

A. Exterior, Alkali-Resistant, Water-Based Primer: Pigmented, water-based primer formulated for use on alkaline surfaces, such as exterior plaster, vertical concrete, and masonry.
1. Manufacturer: Sherwin Williams
2. Product: LOXCON Concrete & Masonry Primer/Sealer

3. Sheen: Flat
4. Product No.: LX02W0050

## 3.8 EXTERIOR PAINTING SCHEDULE, METAL SUBSTRATES

A. Steel and Iron Substrates:

1. Water-Based, Light Industrial Coating System

a. Prime Coat: Zinc-rich, inorganic primer formulated for use on prepared steel subject to severe industrial environments.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Exterior, water-based, light industrial coating, low sheen

B. Galvanized-Metal Substrates:

1. Latex System

a. Prime Coat: Water-based, galvanized-metal primer.
1) Manufacturer: Rust-Oleum
2) Product: Latex Aluminum Primer
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Exterior latex paint, Matte

2. Oil-Based System

a. Prime Coat: Oil-based, galvanized-metal primer.
1) Manufacturer: Rust-Oleum
2) Product: Oil-Based High Performance Clean Metal Primer
3) Product No.: 215969
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Exterior latex paint, Matte

3. Water-Based, Light Industrial Coating System

a. Prime Coat: Water-based, galvanized-metal primer
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Exterior, water-based, light industrial coating, low sheen

C. Aluminum Substrates:

1. Latex System

a. Prime Coat: Quick-drying aluminum primer.
1) Manufacturer: Sherwin Williams
2) Product: A-100 Exterior Fast Dry Stain Blocking Primer
3) Sheen: Flat
4) Product No.: Y24WB8005
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Exterior latex paint, flat

## 3.9 EXTERIOR PAINTING SCHEDULE, WOOD SUBSTRATES

A. Wood-Based Panel Substrates:

1. Latex over Latex Primer System

a. Prime Coat: Exterior, latex fast-dry stain blocking wood primer.
1) Manufacturer: Sherwin Williams
2) Product: A-100 Exterior Fast Dry Stain Blocking Primer
3) Sheen: Flat
4) Product No.: Y24WB8005

b. Intermediate Coat: Matching topcoat.

c. Topcoat: Exterior latex paint, low sheen

## 3.10 EXTERIOR PAINTING SCHEDULE, CEMENTITIOUS SUBSTRATES

A. Exterior, Alkali-Resistant, Water-Based Primer: Pigmented, water-based primer formulated for use on alkaline surfaces, such as exterior plaster, vertical concrete, and masonry.
1. Manufacturer: Sherwin Williams
2. Product: LOXCON Concrete & Masonry Primer/Sealer
3. Sheen: Flat
4. Product No.: LX02W0050

## 3.11 EXTERIOR PAINTING SCHEDULE, MISCELLANEOUS SUBSTRATES

A. Exterior, Latex Block Filler: Water-based, pigmented, high-solids, emulsion coating formulated to bridge and fill porous surfaces of exterior concrete masonry units in preparation for specified subsequent coatings.
1. Minimum Solids Content: Manufacturer's standard percentage solids by volume.
2. Manufacturer: Sherwin Williams
3. Product: LOXCON Water Blocking Primer/Finish
4. Sheen: Flat
5. Product No: LX12W0050

B. Exterior, Alkali-Resistant, Water-Based Primer: Pigmented, water-based primer formulated for use on alkaline surfaces, such as exterior plaster, vertical concrete, and masonry.
1. Manufacturer: Sherwin Williams
2. Product: LOXCON Concrete & Masonry Primer/Sealer
3. Sheen: Flat
4. Product No.: LX02W0050

C. Plastic-Trim-Fabrication Substrates:

1. Latex System

a. Prime Coat: Water-based bonding primer.

b. Intermediate Coat: Matching topcoat.

c. Topcoat: Exterior latex paint, low sheen.

END OF SECTION 099113

SECTION 099123 - INTERIOR PAINTING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Primers.
2. Water-based finish coatings.
3. Solvent-based finish coatings.
4. Floor sealers and paints.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Samples: For each type of topcoat product.

C. Product Schedule: Use same designations indicated on Drawings and in the Interior Painting Schedule to cross-reference paint systems specified in this Section. Include color designations.

1.3 QUALITY ASSURANCE

A. Mockups: Apply mockups of each paint system indicated and each color and finish selected to verify preliminary selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 PAINT PRODUCTS, GENERAL

A. Material Compatibility:

1. Materials for use within each paint system shall be compatible with one another and substrates indicated, under conditions of service and application as demonstrated by manufacturer, based on testing and field experience.
2. For each coat in a paint system, products shall be recommended in writing by topcoat manufacturers for use in paint system and on substrate indicated.

B. Colors: As indicated in a finish schedule.

## 2.3 PRIMERS

A. Interior/Exterior Latex Block Filler: Water-based, high-solids, emulsion coating formulated to bridge and fill porous surfaces of exterior concrete masonry units in preparation for specified subsequent coatings.

B. Alkali-Resistant, Water-Based Primer: Water-based primer formulated for use on alkaline surfaces, such as plaster, vertical concrete, and masonry.

C. Interior, Institutional Low-Odor/VOC Primer Sealer: Water-based primer sealer with low-odor characteristics and a VOC of less than 10 grams per liter for use on new interior plaster, concrete, and gypsum wallboard surfaces that are subsequently to be painted with latex finish coats.

D. Water-Based Galvanized-Metal Primer: Corrosion-resistant, acrylic primer; formulated for use on cleaned/etched, exterior, galvanized metal to prepare it for subsequent water-based coatings.

E. Quick-Drying Aluminum Primer: Corrosion-resistant, solvent-based, alkyd or modified-alkyd primer formulated for quick-drying capabilities and for use on prepared exterior aluminum.

F. Water-Based Bonding Primer: Water-based-emulsion primer formulated to promote adhesion of subsequent specified coatings.

G. Solvent-Based Bonding Primer: Solvent-based primer formulated to seal substrates and promote adhesion of specified subsequent coatings.

## 2.4 WATER-BASED FINISH COATS

A. Interior, Latex, Institutional Low Odor/VOC, Low Sheen: White or colored latex paint with low-odor characteristics and a VOC of less than 10 grams per liter, for use in areas, such as hospitals and other occupied buildings, where the odor and VOC levels of conventional latex products would preclude their use.
   1. Gloss and Sheen Level: Manufacturer's standard low-sheen finish.

B. Interior, Latex, Institutional Low Odor/VOC, Eggshell: White or colored latex paint with low-odor characteristics and a VOC of less than 10 grams per liter, for use in areas, such as hospitals and other occupied buildings, where the odor and VOC levels of conventional latex products would preclude their use.
   1. Gloss and Sheen Level: Manufacturer's standard eggshell finish.

C. Interior, Latex, Institutional Low Odor/VOC, Satin: White or colored latex paint with low-odor characteristics and a VOC of less than 10 grams per liter, for use in areas, such as hospitals and other occupied buildings, where the odor and VOC levels of conventional latex products would preclude their use.
   1. Gloss and Sheen Level: Manufacturer's standard low-sheen finish.

D. Interior, Latex, Institutional Low Odor/VOC, Semigloss: White or colored latex paint with low-odor characteristics and a VOC of less than 10 grams per liter, for use in areas, such as hospitals and other occupied buildings, where the odor and VOC levels of conventional latex products would preclude their use.

1. Gloss Level: Manufacturer's standard semigloss finish.

E. Interior, Latex, Institutional Low-Odor/VOC, Gloss: White or colored latex paint with low-odor characteristics and a VOC of less than 10 grams per liter, for use in areas, such as hospitals and other occupied buildings, where the odor and VOC levels of conventional latex products would preclude their use.
   1. Gloss Level: Manufacturer's standard gloss finish.

F. Interior, Water-Based Light-Industrial Coating, Eggshell: Pigmented, water-based emulsion coating for interior primed wood and metal surfaces (e.g., walls, doors, frames, trim, and sash), providing resistance to moderate abrasion and mild chemical exposure and corrosive conditions.
   1. Gloss and Sheen Level: Manufacturer's standard eggshell finish.

G. Interior, Water-Based Light-Industrial Coating, Semigloss: Pigmented, water-based emulsion coating for interior primed wood and metal surfaces (e.g., walls, doors, frames, trim, and sash), providing resistance to moderate abrasion and mild chemical exposure and corrosive conditions.
   1. Gloss Level: Manufacturer's standard semigloss finish.

H. Interior, Water-Based Light-Industrial Coating, Gloss: Pigmented, water-based emulsion coating for interior primed wood and metal surfaces (e.g., walls, doors, frames, trim, and sash), providing resistance to moderate abrasion and mild chemical exposure and corrosive conditions.
   1. Gloss Level: Manufacturer's standard gloss finish.

I. Interior, Latex, High-Performance Architectural Coating, Low Sheen: High-performance architectural latex coating providing a significantly higher level of performance than conventional latex paints in the areas of scrub resistance, burnish resistance, and ease of stain removal.
   1. Gloss and Sheen Level: Manufacturer's standard low-sheen finish.

J. Interior, Latex, High-Performance Architectural Coating, Eggshell: High-performance architectural latex coating providing a significantly higher level of performance than conventional latex paints in the areas of scrub resistance, burnish resistance, and ease of stain removal.
   1. Gloss and Sheen Level: Manufacturer's standard eggshell finish.

K. Interior, Latex, High-Performance Architectural Coating, Satin: High-performance architectural latex coating providing a significantly higher level of performance than conventional latex paints in the areas of scrub resistance, burnish resistance, and ease of stain removal.
   1. Gloss and Sheen Level: Manufacturer's standard low-sheen finish.

L. Interior, Latex, High-Performance Architectural Coating, Semigloss: High-performance architectural latex coating providing a significantly higher level of performance than conventional latex paints in the areas of scrub resistance, burnish resistance, and ease of stain removal.
   1. Gloss Level: Manufacturer's standard semigloss finish.

## 2.5 SOLVENT-BASED FINISH COATS

A. Aluminum Paint: Aliphatic, solvent-based coating consisting of varnish or alkyd binder combined with aluminum pigment that is formulated for use as a stain-blocking coating and

sealer on wood, metal, bituminous-coated, and prepared masonry surfaces and to be able to be recoated with conventional alkyd and latex paints.

B. Latex Floor Paint, Low Gloss: Water-based, pigmented coating formulated to hide stains, for alkali and incidental water resistance, and for use on concrete and primed-wood surfaces subject to low to medium foot traffic.
   1. Gloss and Sheen Level: Manufacturer's standard low-gloss finish.
   2. Slip-Resistant Aggregate: Manufacturer's standard additive.

C. Water-Based Concrete Floor Sealer: Clear, water-based, acrylic-copolymer-emulsion sealer formulated for oil, gasoline, alkali, and water resistance and for use on concrete traffic surfaces.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify suitability of substrates, including surface conditions and compatibility, with existing finishes and primers.

B. Proceed with coating application only after unsatisfactory conditions have been corrected.

   1. Application of coating indicates acceptance of surfaces and conditions.

### 3.2 PREPARATION

A. Comply with manufacturer's written instructions and recommendations applicable to substrates and paint systems indicated.

B. Remove hardware, covers, plates, and similar items already in place that are removable and are not to be painted. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and painting.

C. After completing painting operations, use workers skilled in the trades involved to reinstall items that were removed. Remove surface-applied protection if any.

### 3.3 INSTALLATION

A. Apply paints according to manufacturer's written instructions.

B. Apply paints to produce surface films without cloudiness, spotting, holidays, laps, brush marks, roller tracking, runs, sags, ropiness, or other surface imperfections. Cut in sharp lines and color breaks.

C. Painting Fire-Suppression, Plumbing, HVAC, Electrical, Communication, and Electronic Safety and Security Work:

   1. Paint the following work where exposed in equipment rooms:

a. Equipment, including panelboards.
b. Uninsulated metal piping.
c. Uninsulated plastic piping.
d. Pipe hangers and supports.
e. Metal conduit.
f. Plastic conduit.
g. Tanks that do not have factory-applied final finishes.
h. Duct, equipment, and pipe insulation having cotton or canvas insulation covering or other paintable jacket material.

2. Paint portions of internal surfaces of metal ducts, without liner, behind air inlets and outlets that are visible from occupied spaces.

## 3.4 CLEANING AND PROTECTION

A. After completing paint application, clean spattered surfaces. Remove spattered paints by washing, scraping, or other methods. Do not scratch or damage adjacent finished surfaces.

B. Protect work of other trades against damage from paint application. Correct damage to work of other trades by cleaning, repairing, replacing, and refinishing, as approved by Architect, and leave in an undamaged condition.

C. At completion of construction activities of other trades, touch up and restore damaged or defaced painted surfaces.

## 3.5 INTERIOR PAINTING SCHEDULE

A. Concrete Substrates, Nontraffic Surfaces:

1. Institutional Low-Odor/VOC Latex System:

a. Prime Coat: Interior, institutional low-odor/VOC primer sealer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior latex, institutional low odor/VOC, eggshell.

2. High-Performance Architectural Latex System:

a. Prime Coat: Alkali-resistant, water based primer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior latex, high-performance architectural coating, eggshell.

3. Water-Based Light-Industrial Coating System:

a. Prime Coat: Alkali-resistant, water-based primer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, water-based, light-industrial coating, eggshell.

4. Alkyd System:

a. Prime Coat: Alkali-resistant, water-based primer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior alkyd, eggshell.

B. Concrete Substrates, Traffic Surfaces:

1. Solvent-Based Concrete Floor Sealer System:

a. First Coat: Matching topcoat.
b. Topcoat: Solvent-based concrete floor sealer.

C. Clay Masonry Substrates:

1. Institutional Low-Odor/VOC Latex System:

a. Prime Coat: Interior, institutional low-odor/VOC primer sealer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, latex, institutional low odor/VOC, satin.

2. High-Performance Architectural Latex System:

a. Prime Coat: Alkali-resistant, water-based primer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, latex, high-performance architectural coating, eggshell.

3. Water-Based Light-Industrial Coating System:

a. Prime Coat: Alkali-resistant, water-based primer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, water-based, light-industrial coating, eggshell.

D. CMU Substrates:

1. Institutional Low-Odor/VOC Latex System Insert drawing designation:

a. Block Filler: Interior/exterior latex block filler.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, latex, institutional low odor/VOC, eggshell.

2. High-Performance Architectural Latex System:

a. Block Filler: Interior/exterior latex block filler.
b. Prime Coat: Alkali-resistant, water-based primer.
c. Intermediate Coat: Matching topcoat.
d. Topcoat: Interior, latex, high-performance architectural coating, eggshell.

3. Water-Based Light-Industrial Coating System:

a. Block Filler: Interior/exterior latex block filler.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, water-based, light-industrial coating, eggshell.

E. Steel Substrates:

1. Institutional Low-Odor/VOC Latex System:

   a. Prime Coat: Water-based rust-inhibitive primer.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, latex, institutional low odor/VOC, flat .

2. High-Performance Architectural Latex System:

   a. Prime Coat: Alkyd quick-dry primer for metal.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Topcoat: Interior, latex, high-performance architectural coating, eggshell.

3. Water-Based Light-Industrial Coating System:

   a. Prime Coat: Primer, rust-inhibitive, water based.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, water-based, light-industrial coating, eggshell.

4. Water-Based Light-Industrial Coating System over Epoxy Primer System:

   a. Prime Coat: Anticorrosive epoxy primer.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, water-based, light-industrial coating, eggshell or semigloss.

F. Galvanized-Metal Substrates:

1. Institutional Low-Odor/VOC Latex System:

   a. Prime Coat: Water-based galvanized primer.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, latex, institutional low odor/VOC, eggshell.

2. High-Performance Architectural Latex System:

   a. Prime Coat: Water-based galvanized primer.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, latex, high-performance architectural coating, eggshell.

G. Gypsum Board Substrates:

1. Institutional Low-Odor/VOC Latex System:

   a. Prime Coat: Interior, institutional low-odor/VOC primer sealer.
   b. Intermediate Coat: Matching topcoat.
   c. Topcoat: Interior, latex, institutional low odor/VOC, eggshell.

2. High-Performance Architectural Latex System:

   a. Prime Coat: Interior latex primer sealer.
   b. Intermediate Coat: Matching topcoat.

c. Topcoat: Interior, latex, high-performance architectural coating, semigloss.

3. Water-Based Light-Industrial Coating System:

a. Prime Coat: Interior latex primer sealer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, water-based, light-industrial coating, semigloss.

4. Alkyd over Latex Sealer System:

a. Prime Coat: Interior latex primer sealer.
b. Intermediate Coat: Matching topcoat.
c. Topcoat: Interior, alkyd, eggshell.

END OF SECTION 099123

SECTION 102113.17 - PHENOLIC-CORE TOILET COMPARTMENTS

1.1 SUMMARY

A. Phenolic-core toilet compartments configured as toilet enclosures

1. Toilet-Enclosure Style: Floor anchored, privacy type.

1.2 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: ASTM E84.

1. Flame-Spread Index: **75** or less.
2. Smoke-Developed Index: 450 or less.

B. Structural Performance: Where grab bars are mounted on toilet compartments, design panels to comply with the following requirements:

1. Panels are able to withstand a concentrated load on grab bar of at least 250 lbf (1112 N) applied at any direction and at any point, without deformation of panel.

C. Regulatory Requirements: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1 for toilet compartments designated as accessible.

1.3 COMPONENTS

A. Door, Panel, and Pilaster Construction: Solid phenolic-core material with melamine facing on both sides. Provide with no-sightline system consisting of door and pilaster lapped edges on strike side of door and door and pilaster lapped edges on hinge side of door (unless continuous hinge is used).

B. Brackets (Fittings):

1. Stirrup Type: Ear or U-brackets; stainless steel.
2. Full-Height (Continuous) Type: Manufacturer's standard design; stainless steel

C. Phenolic Unit Finish: One color in each room.

1. Through-Color Phenolic: Manufacturer's standard solid through-color.

a. Color: As selected by Owner from manufacturer's full range.

1.4 HARDWARE AND ACCESSORIES

A. Door Hardware and Accessories: Manufacturer's heavy-duty stainless steel operating hardware and accessories.

END OF SECTION 102113.17

SECTION 102600 - WALL AND DOOR PROTECTION

1.1 PERFORMANCE REQUIREMENTS

A. Surface Burning Characteristics: Class A.

B. Accessibility requirements of authority having jurisdiction.

C. Coordinate with Owner corner guard and end wall guard locations as needed.

D. Refer to Door Schedule and Door Hardware Sets for door protection.

1.2 PRODUCTS

A. Corner Guards:

1. Surface-Mounted, Plastic-Cover Type: 4 feet (1.2 m)] high, using one-piece aluminum retainer clips, and PVC-free.
2. Surface-Mounted, Opaque-Plastic Type: PVC free plastic or acrylic-modified vinyl sheet
3. Surface-Mounted, Metal Type: Stainless steel

B. End-Wall Guards:

1. Surface-Mounted, Plastic-Cover Type: 4 feet (1.2 m) high, PVC-free.
2. Flush-Mounted, Plastic-Cover Type: 4 feet (1.2 m) high, PVC-free.
3. Surface-Mounted, Metal Type: Stainless steel

C. Door Protection:

1. Protection Plates: Plastic armor kick & push] plates.
2. Door Lever Protector: Plastic.

END OF SECTION 102600

SECTION 102800 – TOILET AND SHOWER ACCESSORIES

1.1 GENERAL

1. Refer to Drawings for Manufacturer and Model Number Information.

1.2 WARRANTY

A. Silver Spoilage for Mirrors: **15** years.

B. Toilet-Compartment Occupancy-Indicator System: **Five** years.

1.3 PRODUCTS

A. Public-Use Washroom Accessories:

1. Toilet tissue (roll) dispenser.
2. Automatic paper towel (roll) dispenser.
3. Waste receptacle.
4. Soap dispenser.
5. Grab bar.
6. Sanitary-napkin disposal unit.
7. Seat-cover dispenser.
8. Mirror unit.
9. Hook.

B. Toilet-compartment occupancy-indicator system.

C. Public-Use Shower Room Accessories:

1. Shower curtain rod.
2. Shower curtain.
3. Folding shower seat.
4. Soap dish.
5. Robe hook.

D. Underlavatory guards.

E. Custodial Accessories:

1. Utility shelf.
2. Mop and broom holder.

F. Hand-Sanitizer Dispensers:

1. Hand-sanitizer dispenser.
2. Automatic hand-sanitizer dispenser.

END OF SECTION 102800

SECTION 105129 - PHENOLIC LOCKERS

1.1 SUMMARY

A. Section Includes”
1. Phenolic lockers.
2. Phenolic locker benches.

B. ACTION SUBMITTALS:
1. Product Data

C. INFORMATIONAL SUBMITTALS
1. Material Test Reports
2. Sample Warranties

D. QUALITY ASSURANCE
1. Entity that employs installers and supervisors who are trained and approved by Manufacturer.

E. WARRANTY
1. Special Warranty: Manufacturer agrees to repair or replace components of lockers that fail in materials or workmanship within specified warranty period.
a. Warranty Period: Ten years from date of Substantial Completion.

1.2 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E84 or UL 723; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 450 or less.

B. Accessibility Regulations: Comply with applicable provisions in the USDOJ's "2010 ADA Standards for Accessible Design" and ICC A117.1 for lockers and locker benches designated as accessible.

C. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design seismic restraint of lockers.

1.3 PHENOLIC LOCKERS

A. Phenolic Lockers:

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

1. ASI Storage Solutions.
2. Club Resource Group.

3. Hollman, Inc.
4. Ideal Products, Inc.
5. List Industries Inc.
6. Partition Systems International of South Carolina (PSISC); Columbia Systems International of South Carolina LLC.
7. Or Approved Equal

C. Construction Style: Manufacturer's standard factory-assembled flush overlay units.

D. Locker Body: Solid phenolic-core material with melamione facing on both sides fused to substrate during manufacture (not separately laminated), and with beveled and polished edges.
1. Thickness:
a. Side Panels: 5/8 inch
b. Back Panel: 3/8 inch
c. Top Panel: 5/8 inch
d. Bottom Panel: 5/8 inch

E. Doors: Solid phenolic-core material with melamine facing on both sides fused to substrate during manufacture (not separately laminated), and with beveled and polished edges.
1. Thickness: 1/2 inch

F. End Panels: Match style, material, construction and finish of doors.

G. Fixed Shelves: Match style, material, construction and finish of locker body.
1. Thickness: 5/8 inch

H. Corners and Filler Panels: Match style, material, construction, thickness, and finish of doors; fabricated in lengths as long as practical to enclose base and base ends of lockers.

I. Phenolic Locker Finish:

1. Black-Core Phenolic:

a. Facing Sheet Color:

1) Locker Body: Manufacturer's standard color – Selected by Architect
2) Doors: As indicated by manufacturer's designations

b. Exposed Edges: Manufacturer's standard black edge.

J. Wood Support Base: 2-by-4-inch nominal (51-by-102-mm actual)-size lumber treated with manufacturer's standard preservative-treatment, pressure process

K. Hardware:

1. Locking Device: Built-in pushbutton combination lock and Padlock Option – Coordinate with Owner.
2. Hinges: Manufacturer's Standard - Frameless (European) – fully concealed, self-closing, with not less than 110 degrees of opening. Manufacturer's standard material and finish.
3. Handle:
a. Wire Pulls: Back Mounted

b. Size: 5 inches long
c. Accessible Handle: Metal fixed graspable lever handle and rose trim; surface mounted.

4. Hooks: Ball-pointed hooks. Attach hooks with at least two-fasteners. Manufacturer's standard.
5. Coat Rods:
a. Size: 1 inch – Manufacturer's standard diameter steel.
b. Provide coat rod for each compartment of double-tier lockers.

L. Accessories:

1. Number plates – Manufacturer's Standard.

1.4 PHENOLIC LOCKER BENCHES:

A. Size: (12) 4'-0" W x 1'-8" D Bench with metal pedestal legs mounted to floor.

B. Finish: Black Core Phenolic: Face Sheet Color: As selected by Architect from manufacturer's full range.

C. Bench Supports:

1. Tube Pedestal Supports: Manufacturer's standard 1-1/2-inch- (38-mm-) diameter, tubular pedestal supports with predrilled fastener holes for attaching bench top and anchoring to floor, complete with fasteners and anchors, minimum of two pedestals for each bench.

2. Material: Powder-coated steel to match lockers.

1.5 MATERIALS

A. Anchors: Material, type, size, and finish as required for each substrate for secure anchorage. Provide metal expansion sleeves or expansion bolts for post-installed anchors. Use nonferrous-metal or hot-dip galvanized anchors and inserts at inside face of exterior walls and at floors.

1.6 FABRICATION

A. Fabricate each locker with shelves, an individual door and frame, an individual top, a bottom, and a back, and with common intermediate uprights separating compartments.

1. Fabricate lockers to dimensions, profiles, and details indicated.

B. Fabricate lockers square, rigid, without warp, and with finished faces flat and free of dents, scratches, and chips. Accurately factory machine components for attachments. Make joints tight and true.

C. Accessible Lockers: Fabricate as follows:

1. Locate bottom shelf no lower than 15 inches (381 mm) above the floor.

2. Where hooks, coat rods, or additional shelves are provided, locate no higher than 48 inches (1219 mm) above the floor.

D. Venting: Fabricate lockers with space between doors and locker assembly of not less than 1/4 inch (6 mm).

E. Complete fabrication, including assembly, finishing, and hardware application, to maximum extent possible, before shipment to Project site. Disassemble components only as necessary for shipment and installation. Where necessary for fitting at site, provide ample allowance for scribing, trimming, and fitting.

1. Use only manufacturer's nuts, bolts, screws, and other devices for assembly.

F. Shop cut openings, to maximum extent possible, to receive hardware, electrical work, and similar items. Locate openings accurately and use templates or roughing-in diagrams to produce accurately sized and shaped openings. Sand edges of cutouts to remove splinters and burrs.

## PART 2 - EXECUTION

### 2.1 INSTALLATION

A. Install wood support base with 1/2-inch- (13-mm-) thick, plywood top.

B. Install lockers level, plumb, and true; shim as required, using concealed shims.

1. Connect single rows of lockers together side-to-side at each locker. Use manufacturer's standard connecting bolts, through predrilled holes, with no exposed fasteners on face frames. Fit lockers accurately together to form flush, tight, hairline joints.
2. Anchor locker runs at ends and at intervals recommended by manufacturer, but not more than 36 inches (910 mm) o.c., using manufacturer's standard concealed fasteners for material indicated.

a. Anchor single rows of lockers to walls near top [**and bottom of lockers**] [**of lockers and to wood support base**].
b. Anchor back-to-back lockers to wood support base.
c. Install seismic restraints.

C. Install lockers without distortion so doors fit openings properly and are accurately aligned. Adjust hardware to center doors in openings, providing unencumbered operation. Complete installation of hardware and accessory items as indicated.

D. Installation Tolerance: No more than 1/8 inch in 96-inch (3 mm in 2400-mm) sag, bow, or other variation from a straight line. Shim as required with concealed shims.

E. Scribe and cut corner and filler panels to fit adjoining work using fasteners concealed where practical. Repair damaged finish at cuts.

F. Install number identification plates after lockers are in place.

1. Attach number identification plate on each locker door, near top, centered, with at least two screws with finish matching the plate.

G. Locker Benches: Place benches in locations indicated on Drawings.

END OF SECTION 105129

SECTION 115313 - LABORATORY FUME HOODS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Floor-mounted laboratory fume hoods.
2. Piping and wiring within fume hoods for service fittings, light fixtures, fan switches, and other electrical devices included with fume hoods.
3. Fume hood base cabinets.
4. Fume hood base stands.
5. Work tops within fume hoods.
6. Laboratory sinks and cup sinks in fume hoods.
7. Water, laboratory gas, and electrical service fittings in fume hoods.

1.2 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For laboratory fume hoods.

1. Include plans, elevations, sections, and attachment details.
2. Indicate details for anchoring fume hoods to permanent building construction including locations of blocking and other supports.
3. Indicate locations and types of service fittings together with associated service supply connection required.
4. Indicate duct connections, electrical connections, and locations of access panels.
5. Include roughing-in information for mechanical, plumbing, and electrical connections.

C. Samples: None

D. Delegated Design Submittals: For fume hoods indicated to comply with seismic performance requirements and design criteria.

1.3 INFORMATIONAL SUBMITTALS

A. Product Test Reports: Showing compliance with specified performance requirements for as-manufactured containment and static pressure loss, based on evaluation of comprehensive tests performed by manufacturer and witnessed by a qualified testing agency.

B. Field quality-control reports.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Bypass Fume Hoods with Steel Exterior:

1. Manufacturers: Subject to compliance with requirements, Owner provided product by the following:

a. Labconco.
1) Model Name: Basic 47 Laboratory Fume Hood – with Blower Module
a) Type: By-pass airflow design
b) Model No.: 2247300
c) Size: 48 inches Wide x 25 inches Deep x 53 inches High
d) Exhaust Duct Size: 10.3 inches OD

2.2 PERFORMANCE REQUIREMENTS

A. Containment: Provide fume hoods that comply with the following when tested according to ASHRAE 110:
1. Average Face Velocity: **100 fpm (0.51 m/s)** plus or minus 10 percent with sashes fully open.

B. Static-Pressure Loss: Not more than **1/4-inch wg (124 Pa)** at **100-fpm (0.51-m/s)** face velocity with sash fully open when measured at four locations 90 degrees apart around the exhaust duct and at least three duct diameters downstream from duct collar.

2.3 FUME HOODS

**A.** Product Standards: Comply with SEFA 1, "Laboratory Fume Hoods - Recommended Practices**."** Provide fume hoods UL listed and labeled for compliance with UL 1805.

B. Bypass Fume Hoods: Provide bypass fume hoods where indicated. Compensating bypass above the sash opens as sash is closed. Provide sufficient bypass capacity so that face velocity with sash opening of 6 inches (150 mm) does not exceed 3 times the face velocity with sash fully open.

2.4 MATERIALS

A. Steel Sheet: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

B. Stainless Steel Sheet: ASTM A240/A240M or ASTM A666, Type 304, stretcher-leveled standard of flatness.

1. For perchloric acid fume hoods, use Type 316L instead of Type 304.

C. Glass-Fiber-Reinforced Polyester: Polyester laminate with a chemical-resistant gel coat on exposed faces, and having a flame-spread index of 25 or less according to ASTM E84.

D. Epoxy: Factory-molded, modified epoxy-resin formulation with smooth, nonspecular finish.

1. Physical Properties:

a. Flexural Strength: Not less than 10,000 psi (70 MPa).
b. Modulus of Elasticity: Not less than 2,000,000 psi (1400 MPa).
c. Hardness (Rockwell M): Not less than 100.
d. Water Absorption (24 Hours): Not more than 0.02 percent.
e. Heat Distortion Point: Not less than 260 deg F (127 deg C).
f. Flame-Spread Index: 25 or less according to ASTM E84.

2. Chemical Resistance: As follows when tested with indicated reagents according to NEMA LD 3, Test Procedure 3.4.5:

a. No Effect: Acetic acid (98 percent), acetone, ammonium hydroxide (28 percent), benzene, carbon tetrachloride, dimethyl formamide, ethyl acetate, ethyl alcohol, ethyl ether, methyl alcohol, nitric acid (70 percent), phenol, sulfuric acid (60 percent), and toluene.
b. Slight Effect: Chromic acid (60 percent) and sodium hydroxide (50 percent).

3. Color: Black.

E. Polypropylene: Unreinforced polypropylene complying with ASTM D4101, Group 01, Class 1, Grade 2.

F. Glass: Clear, laminated tempered glass complying with ASTM C1172, Kind LT, Condition A, Type I, Class I, Quality-Q3; with clear, polyvinyl butyral interlayer.
1. Thickness: 3/16 inch thick

2. Permanently mark safety glass with certification label of the SGCC or the manufacturer. Label to indicate manufacturer's name, type of glass, thickness, and safety glazing standard with which glass complies.

G. 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.

H. Fasteners: Provide stainless steel fasteners where exposed to fumes.

## 2.5 FABRICATION

A. General: Assemble fume hoods in factory to greatest extent possible. Disassemble fume hoods only as necessary for shipping and handling limitations. Fume hoods to be capable of being partly disassembled as necessary to permit movement through a 35-by-79-inch (889-by-2007-mm) door opening.

B. Steel Exterior: Fabricate from steel sheet, 0.051 inch (1.21 mm) thick, with component parts screwed together to allow removal of end panels, front fascia, and airfoil and to allow access to

plumbing lines and service fittings. Apply chemical-resistant finish to interior and exterior surfaces of component parts before assembly.

C. Ends: Fabricate with double-wall end panels without projecting corner posts or other obstructions to interfere with smooth, even airflow. Close area between double walls at front of fume hood and as needed to house sash counterbalance weights, utility lines, and remote-control valves.

D. Splay top and sides of face opening to provide an aerodynamic shape to ensure smooth, even flow of air into fume hood.

E. Interior Lining: Provide the following unless otherwise indicated:
   1. Powder coated steel, not less than 0.051 inch (1.27 mm) (16 Gauge) thick.

F. Lining Assembly: Unless otherwise indicated, assemble with stainless steel fasteners or epoxy adhesive, concealed where possible. Seal joints by filling with chemical-resistant sealant during assembly.
   1. Fasten lining components to a rigid frame assembly fabricated from steel and to which exterior panels are attached.
   2. Punch fume hood lining side panels to receive service fittings and remote controls. Provide removable plug buttons for holes not used for indicated fittings.

G. Exhaust Plenum: Full width of fume hood and with adequate volume to provide uniform airflow from hood, of same material as hood lining, and with duct stub for exhaust connection.

   1. Duct-Stub Material: Epoxy-coated steel

H. Bypass Grilles: Provide grilles at bypass openings of fume hoods.

I. Light Fixtures: Provide vaporproof, light bulb. Shield bulbs from hood interior with 1/4-inch-(6.35-mm-) thick laminated glass or 3-mm-thick tempered glass, sealed into hood with chemical-resistant rubber gaskets. Provide units with LED light easily replaceable from outside of fume hood.

   1. Provide vapor-proof LED light with color temperature of 3500 K and minimum color-rendering index of 85 if available.

J. Filler Strips: Provide as needed to close spaces between fume hoods or fume hood base cabinets and adjacent building construction. Fabricate from same material and with same finish as fume hoods or fume hood base cabinets, as applicable.

K. Ceiling Extensions: Provide filler panels matching fume hood exterior to enclose space above fume hoods at front and sides of fume hoods and extending from tops of fume hoods to ceiling.

L. Finished Back and Right-Side Finish Panels: Where rear surfaces of fume hoods are exposed to view, provide finished back panels matching rest of fume hood enclosure.

M. Comply with requirements in other Sections for installing water and laboratory gas service fittings, piping, electrical devices, and wiring. Install according to Shop Drawings. Securely anchor fittings, piping, and conduit to fume hoods unless otherwise indicated.

## 2.6 FUME HOOD BASE CABINETS, WORK TOPS, SINKS AND SERVICE FITTINGS

A. Comply with Section 123553.13 "Metal Laboratory Casework." Provide metal base cabinets in finish matching fume hood exterior finish.

B. Work Tops: Epoxy
   1. Where epoxy sinks occur in epoxy work tops, provide integral sinks bonded to tops with invisible joint line.
   2. Catalog Number: 4882803
   3. Dimensions: 48 inches wide X 30 inches deep X 1.25 inches thickness

C. Cup Sinks: Epoxy, 3-by-6-inch (75-by-150-mm) oval, material and size as indicated. Coordinate with Owner.
   1. Provide **epoxy** cup sinks with polypropylene strainers and integral tailpieces.
   2. Provide stainless steel cup sinks with stainless steel strainers and integral tailpieces.

D. Fume Hood Base Stands: Welded steel tubing legs, not less than 2 inches (50 mm) square with channel stretchers and aprons. Weld or bolt stretchers to legs and cross-stretchers, and bolt legs to aprons. Provide leveling device welded to bottom of each leg.

## 2.7 CHEMICAL-RESISTANT FINISH

A. Preparation: Clean steel surfaces, other than stainless steel, of mill scale, rust, oil, and other contaminants. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.

B. Chemical-Resistant Finish: Immediately after cleaning and pretreating, apply fume hood manufacturer's standard two-coat, chemical-resistant, baked-on finish consisting of prime coat and thermosetting topcoat. Comply with coating manufacturer's written instructions for applying and baking to achieve a minimum dry film thickness of 2 mils (0.05 mm).

   1. Chemical and Physical Resistance of Finish System: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8M. Acceptance level for chemical spot test to be no more than four Level 3 conditions.
   2. Colors for Fume Hood Finish: As indicated by manufacturer's designations.

## 2.8 ACCESSORIES

A. Coordinate fume hood and base cabinet accessories with Owner.

B. Airflow Indicator and Alarm: Provide each fume hood with manufacturer's standard airflow indicator with audible and visual alarm that activates when airflow sensor reading is outside of preset range.

C. Airflow Indicator: Provide fume hood with airflow indicator of one of the following type(s):

   1. Indicator Type: Direct-reading aneroid (Magnehelic-type) gage that measures exhaust duct static pressure of fume hood as an indication of airflow.

2. Indicator Type: Thermal anemometer that measures fume hood face velocity and indicates whether it is below normal, normal, or above normal.
3. Indicator Type: Thermal anemometer that measures fume hood face velocity and displays data as digital readout.

D. Airflow Alarm: Provide fume hoods with audible and visual alarm that activates when airflow sensor reading is outside of preset range.

1. Provide with thermal-anemometer or aneroid (Magnehelic-type) gage airflow sensor.
2. Provide with reset and test switches.
3. Provide with switch that silences audible alarm and automatically resets when airflow returns to within preset range.

E. Sash Alarm: Provide fume hoods with audible and visual alarm that activates when sash is opened beyond preset position.

1. Provide with silence and test switches.

F. Sash Stops: Provide fume hoods with sash stops to limit hood opening to 50 percent of sash height. Sash stops can be manually released to open sash fully for cleaning fume hood and for placing large apparatus within fume hood.

G. Bypass Grille Blank-off Panel: Provide fume hoods with blank-off panel on bypass grille designed for use with sash stops to reduce exhaust air volume and provide design face velocity with sash at 50 percent open position.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. General: Install fume hoods according to manufacturer's written instructions. Install level, plumb, and true; shim as required, using concealed shims, and securely anchor to building and adjacent laboratory casework. Securely attach access panels but provide for easy removal and secure reattachment. Where fume hoods abut other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Comply with requirements for installing water and laboratory gas service fittings and electrical devices.

1. Install fittings according to Shop Drawings, installation requirements in SEFA 2.3, and manufacturer's written instructions. Set bases and flanges of sink and work top-mounted fittings in sealant recommended by manufacturer of sink or work-top material. Securely anchor fittings to fume hoods unless otherwise indicated.

### 3.2 FIELD QUALITY CONTROL

A. Field test installed fume hoods according to ASHRAE 110 to verify compliance with performance requirements.

1. Adjust fume hoods, hood exhaust fans, and building's HVAC system, or replace hoods and make other corrections until tested hoods perform as specified.
2. After making corrections, retest fume hoods that failed to perform as specified.

END OF SECTION 115313

SECTION 123553.13 - METAL LABORATORY CASEWORK

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Metal laboratory casework.
2. Countertops.
3. Laboratory accessories.
4. Water and laboratory service fittings.

1.2 PREINSTALLATION MEETINGS

A. Preinstallation Conference: Conduct conference at Project site.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For laboratory casework. Include plans, elevations, sections, and attachments to other work including blocking and reinforcements required for installation.

C. Samples: For casework finishes and materials requiring color selection.

D. Delegated Design Submittals: For laboratory casework indicated to comply with seismic performance requirements, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.4 INFORMATIONAL SUBMITTALS

A. Product test reports.

PART 2 - PRODUCTS

2.1 METAL LABORATORY CASEWORK

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

1. BMC, Inc.
2. Hamilton Laboratory Solutions, LLC.
3. ICIscientific.

4. Kewaunee Scientific Corporation.
5. Lab Crafters, Inc.
6. Mott Manufacturing Ltd.
7. Multi-Lab, Inc.

B. Product Designations: Drawings indicate sizes and configurations of laboratory casework by referencing designated manufacturer's catalog numbers. Other manufacturers' laboratory casework of similar sizes and similar door and drawer configurations and complying with Specifications may be considered. See Section 016000 "Product Requirements."

## 2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design laboratory casework installation.

## 2.3 CASEWORK, GENERAL

A. Casework Product Standard: Comply with SEFA 8 M, "Laboratory Grade Metal Casework."

B. Flammable Liquid Storage: Where cabinets are indicated for solvent or flammable liquid storage, provide units that are listed and labeled as complying with requirements in NFPA 30 by a testing and inspecting agency acceptable to authorities having jurisdiction.

C. 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.

## 2.4 METAL CASEWORK MATERIALS

A. Steel Sheet: Cold-rolled, commercial steel (CS) sheet, complying with ASTM A1008/A1008M; matte finish; suitable for exposed applications.

## 2.5 CABINET HARDWARE

A. General: Provide laboratory casework manufacturer's standard, commercial-quality, heavy-duty hardware complying with requirements indicated for each type.

B. Drawer Pulls: Stainless steel , back-mounted pulls.

C. Drawer Slides: Manufacturer's standard; complying with ANSI/BHMA A156.9.

## 2.6 COUNTERTOPS

A. General: Provide laboratory tabletops and countertops with integral sink as indicated on Drawings.

B. Stainless Steel Sheet: ASTM A240/A240M, Type 304

1. Chemical Resistance: Minimum acceptable chemical-resistance performance is to result in no more than four Level 3 conditions when tested with indicated reagents in accordance with SEFA 3.

2. Color: Stainless Steel

## 2.7 METAL CABINET FABRICATION

A. Fabrication: Assemble and finish units at point of manufacture. Use precision dies for interchangeability of like-size drawers, doors, and similar parts. Perform assembly on precision jigs to provide units that are square. Reinforce units with angles, gussets, and channels. Except where otherwise specified, integrally frame and weld cabinet bodies to form dirt- and vermin-resistant enclosures. Where applicable, reinforce base cabinets for sink support. Maintain uniform clearance around door and drawer fronts of 1/16 to 3/32 inch (1.5 to 2.4 mm).

B. Drawers: Fronts made from outer and inner pans that nest into box formation, without raw metal edges at top. Sides, back, and bottom fabricated in one piece with rolled or formed top of sides for stiffening and comfortable grasp for drawer removal. Provide drawers with rubber bumpers, polymer roller slides, and positive stops to prevent metal-to-metal contact or accidental removal.

C. Adjustable Shelves: Front, back, and ends formed down, with edges returned horizontally at front and back to form reinforcing channels.

D. Toe Space: Fully enclosed, 4 inches (100 mm) high by 3 inches (75 mm) deep, with no open gaps or pockets.

E. Tables: Welded tubing legs, not less than 2 inches (50 mm) square with channel stretchers as needed to comply with product standard. Weld or bolt stretchers to legs and cross-stretchers, and bolt legs to table aprons. Provide leveling device welded to bottom of each leg.

1. Leg Shoes: Stainless steel, open-bottom, slip-on type.

F. Utilities: Provide space, cutouts, and holes for pipes, conduits, and fittings in cabinet bodies to accommodate utility services and their support-strut assemblies.

1. Provide base cabinets with removable backs for access to utility space.

G. Utility-Space Framing: Steel framing units consisting of two steel slotted channels complying with MFMA-4, not less than 1-5/8 inches (41 mm) square by 0.105-inch (2.66-mm) nominal thickness, that are connected at top and bottom by U-shaped brackets made from 1-1/4-by-1/4-inch (32-by-6-mm) steel flat bars. Framing units may be made by welding channel material into rectangular frames instead of using U-shaped brackets.

H. Filler and Closure Panels: Provide where indicated and as needed to close spaces between casework and walls, ceilings, and equipment. Fabricate from same material and with same finish as casework and with hemmed or flanged edges unless otherwise indicated.

## 2.8 METAL CABINET FINISH

A. Chemical-Resistant Finish: Finish complies with acceptance levels of cabinet surface finish tests in SEFA 8 M. Acceptance level for chemical spot test to be no more than for Level 3 conditions.

## 2.9 COUNTERTOP FABRICATION

A. Countertops, General: Provide units with smooth surfaces in uniform plane, free of defects. Make exposed edges and corners straight and uniformly beveled. Provide front and end overhang of 1 inch (25 mm).

B. Sinks, General: Provide sizes indicated or laboratory casework manufacturer's closest standard size of equal or greater volume, as approved by Architect.

1. Outlets: Provide with strainers and tailpieces, NPS 1-1/2 (DN 40), unless otherwise indicated.
2. Overflows: Where indicated, provide overflow of standard beehive or open-top design with separate strainer. Height 2 inches (50 mm) less than sink depth. Provide in same material as strainer.

C. Stainless Steel Shelves: Made from stainless steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness, with No. 4 satin finish. Weld shop-made joints. Fold down front edge 3/4 inch (19 mm); fold up back edge 3 inches (75 mm).

1. Provide integral stiffening brackets, formed by folding up ends 3/4 inch (19 mm) and welding to upturned front and back edges.
2. After fabricating, grind welds smooth and polish to produce uniform, directionally textured finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.

D. Stainless Steel Sinks: Made from stainless steel sheet, not less than 0.050-inch (1.27-mm) nominal thickness. Fabricate with corners rounded and coved to at least 5/8-inch (16-mm) radius. Slope sink bottoms to outlet. Provide continuous butt-welded joints.

1. Provide double-wall construction for sink partitions with top edge rounded to at least 1/2-inch (13-mm) diameter.
2. After fabricating and welding, grind surfaces smooth and polish to produce uniform finish with no cross scratches or evidence of welds. Passivate and rinse surfaces; remove embedded foreign matter and leave surfaces clean.
3. Factory punch holes for fittings.
4. Provide with stainless steel strainers and tailpieces.
5. Provide with integral rims except where located in stainless steel countertops.
6. Apply 1/8-inch- (3-mm-) thick coating of heat-resistant, sound-deadening mastic to undersink surfaces.

## 2.10 LABORATORY ACCESSORIES

A. Reagent Shelves: Provide as indicated, fabricated from same material as adjacent countertop unless otherwise indicated.

B. Upright Rod Assembly and Metal Crossbar: Aluminum or stainless steel. Two vertical rods and one horizontal crossbar, 3/4 inch (19 mm) in diameter and 36 inches (900 mm) long unless otherwise indicated; two flush socket receptacles and two crossbar clamps. Ends of vertical rods are tapered to fit receptacles; other rod ends are rounded.

C. Stainless Steel Pegboards: Stainless steel pegboards with removable polypropylene pegs and stainless steel drip troughs with drain outlet.

## 2.11 SERVICE FITTINGS

A. Service Fittings, General: Provide units complete with metal housings, receptacles, switches, pilot lights, data communication outlets, cover plates, accessories, and gaskets required for mounting on laboratory casework.

B. Electrical Wiring Devices: Comply with requirements in Section 262726 "Wiring Devices" for receptacles, switches, pilot lights, cover plates, and accessories.

C. Twisted-Pair Copper Data Outlets: Comply with requirements in Section 271513 "Communications Copper Horizontal Cabling."

D. Optical-Fiber Data Outlets: Comply with requirements Section 271523 "Communications Optical Fiber Horizontal Cabling."

E. Electrical Receptacles: Hospital grade. 125 V, 20 A; NEMA WD 6, Configuration 5-20R unless otherwise indicated.

1. GFCI Receptacles: Feed-through type with integral LED indicator light.
2. SPD Receptacles: With LED indicator light and integral SPD in line to ground, line to neutral, and neutral to ground.
3. Color of Receptacles: As selected by Architect unless otherwise indicated or required by NFPA 70.

F. USB Charger Receptacles: Quad, Type A, color matching electrical receptacles.

1. Type: Hospital grade.

G. Switches: Comply with NEMA WD 1, UL 20, and FS W-S-896.

1. Color of Switches: As selected by Architect unless otherwise indicated or required by NFPA 70.

H. Data Communication Outlets: Two RJ-45 jacks for terminating 100-ohm, balanced, four-pair twisted-pair cabling complying with TIA-568-C.1; complying with Category 6. Comply with UL 1863.

I. Cover Plates: Provide satin-finish, Type 304, stainless steel cover plates with formed, beveled edges.

J. Cover-Plate Identification: Use 1/4-inch- (6-mm-) high letters unless otherwise indicated. For stainless steel or chrome-plated metal, stamp or etch plate and fill in letters with black enamel.

1. Provide at every cover plate.

a. Receptacles other than standard 125-V duplex, grounding type.
b. Switches and thermal-overload switches.
c. Pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Receptacles, switches, and other locations indicated.

2. Provide the following information:

a. Voltage and phase for receptacles other than standard 125-V duplex, grounding type.
b. Indicate equipment being controlled by switches and thermal-overload switches.
c. Indicate equipment being controlled for pilot lights when located remotely from associated equipment or switch, where function is not obvious.
d. Number of the breaker in panelboard that controls device.

K. Pedestal-Type Fittings: Cast-aluminum housings with sloped single face or two faces, as indicated, with neoprene gasket under base and with concealed mounting holes in base for attaching to laboratory casework. Provide holes tapped for conduits.

L. Line-Type Fittings: Provide with cast-metal boxes with threaded holes for mounting on rigid steel conduit. Provide cover plates same size as boxes.

M. Recessed-Type Fittings: Provide with galvanized-steel boxes.

N. Finishes for Service-Fitting Components: Provide housings or boxes for pedestal- and line-type fittings with manufacturer's standard baked-on, chemical-resistant enamel in color as selected by Architect from manufacturer's full range.

## PART 3 - EXECUTION

### 3.1 INSTALLATION OF CABINETS

A. Comply with installation requirements in SEFA 2. Install level, plumb, and true in line; shim as required using concealed shims. Where laboratory casework abuts other finished work, apply filler strips and scribe for accurate fit, with fasteners concealed where practical.

B. Utility-Space Framing: Secure to floor with two fasteners at each frame. Fasten to partition framing, wood blocking, or metal reinforcements in partitions and to base cabinets.

C. Base Cabinets: Fasten cabinets to utility-space framing, partition framing, wood blocking, or reinforcements in partitions, with fasteners spaced not more than 16 inches (400 mm) o.c. Bolt adjacent cabinets together with joints flush, tight, and uniform.

1. Where base cabinets are installed away from walls, fasten to floor at toe space at not more than 24 inches (600 mm) o.c. and at sides of cabinets with not less than two fasteners per side.

D. Wall Cabinets: Fasten to hanging strips, masonry, partition framing, blocking, or reinforcements in partitions. Fasten each cabinet through back, near top, at not less than 16 inches (400 mm) o.c.

E. Install hardware uniformly and precisely.

F. Adjust operating hardware so drawers align and operate smoothly without warp or bind and contact points meet accurately. Lubricate operating hardware as recommended by manufacturer.

## 3.2 INSTALLATION OF COUNTERTOPS

A. Comply with installation requirements in SEFA 2. Abut top and edge surfaces true in plane with flush hairline joints and with internal supports placed to prevent deflection. Locate joints where indicated on Shop Drawings.

B. Field Jointing: Where possible, make in same manner as shop-made joints, using dowels, splines, fasteners, adhesives, and sealants recommended by manufacturer. Shop prepare edges for field-made joints.

C. Fastening:
1. Secure epoxy countertops to cabinets with epoxy cement, applied at each corner and along perimeter edges at not more than 48 inches (1200 mm) o.c.
2. Where necessary to penetrate countertops with fasteners, countersink heads approximately 1/8 inch (3 mm) and plug hole flush with material equal to countertop in chemical resistance, hardness, and appearance.

D. Provide holes and cutouts required for service fittings.

E. Provide scribe moldings for closures at junctures of countertop, curb, and splash with walls as recommended by manufacturer for materials involved. Match materials and finish to adjacent laboratory casework. Use chemical-resistant, permanently elastic sealing compound where recommended by manufacturer.

F. Dress joints smooth, remove surface scratches, and clean entire surface.

## 3.3 INSTALLATION OF SINKS

A. Underside Installation of Stainless Steel Sinks: Use laboratory casework manufacturer's recommended adjustable support system for table- and cabinet-type installations. Set top edge of sink unit in sink and countertop manufacturers' recommended chemical-resistant sealing compound or adhesive, and firmly secure to produce a tight and fully leakproof joint. Adjust sink and securely support to prevent movement. Remove excess sealant or adhesive while still wet and finish joint for neat appearance.

## 3.4 INSTALLATION OF LABORATORY ACCESSORIES

A. Install accessories according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions.

B. Securely fasten adjustable shelving supports, stainless steel shelves, and pegboards to partition framing, wood blocking, or reinforcements in partitions.

C. Install shelf standards plumb and at heights to align shelf brackets for level shelves. Install shelving level and straight, closely fitted to other work where indicated.

D. Securely fasten pegboards to partition framing, wood blocking, or reinforcements in partitions.

## 3.5 INSTALLATION OF SERVICE FITTINGS

A. Comply with requirements in other Sections for installing water and laboratory gas service fittings and electrical devices.

B. Install fittings according to Shop Drawings, installation requirements in SEFA 2, and manufacturer's written instructions. Set bases and flanges of sink- and countertop-mounted fittings in sealant recommended by manufacturer of sink or countertop material. Securely anchor fittings to laboratory casework unless otherwise indicated.

## 3.6 CLEANING AND PROTECTING

A. Clean finished surfaces, touch up as required, and remove or refinish damaged or soiled areas to match original factory finish, as approved by Architect.

B. Protect countertop surfaces during construction with 6-mil (0.15-mm) plastic or other suitable water-resistant covering. Tape to underside of countertop at a minimum of 48 inches (1200 mm) o.c.

## 3.7 SERVICE-FITTING SCHEDULE

A. Water Service Fitting, Type WF-[1].

1. Fitting Type: Rigid, gooseneck mixing faucet.
2. Mounting: Line mounted.

B. Electrical Service Fitting, Type EF-[#].

1. Fitting Type: [Pedestal, single faced] [Pedestal, double faced] [Recessed] [Line mounted].
2. Device: [One duplex receptacle] [Two duplex receptacles] [Four duplex receptacles] [One switched receptacle] [One duplex receptacle, switch, and pilot light].
3. Additional Requirements: [GFCI] [SPD] receptacles.

C. Communication Service Fitting, Type CF-[#].

1. Fitting Type: [Pedestal, single faced] [Pedestal, double faced] [Recessed] [Line mounted].
2. Device: [One duplex communication receptacle] [Two duplex receptacles].

D. Electrical and Communication Service Fitting, Type ECF-[#].

1. Fitting Type: [Pedestal, single faced] [Pedestal, double faced] [Recessed] [Line mounted].
2. Device: [One duplex receptacle and one duplex communication receptacle] [Two duplex receptacles and two duplex communication receptacles] [One switched receptacle and one duplex communication receptacle].
3. Additional Requirements: [GFCI] [SPD] receptacles.

END OF SECTION 123553.13

SECTION 123661.16 - SOLID SURFACING COUNTERTOPS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Solid surface material countertops.
2. Solid surface material backsplashes.
3. Solid surface material end splashes.
4. Solid surface material sinks.

1.2 ACTION SUBMITTALS

A. Product Data: For countertop materials and sinks.

B. Shop Drawings: For countertops. Show materials, finishes, edge and backsplash profiles, methods of joining, and cutouts for plumbing fixtures.

C. Samples: For each type of material exposed to view.

PART 2 - PRODUCTS

2.1 SOLID SURFACE COUNTERTOP MATERIALS

A. Solid Surface Material: Homogeneous-filled plastic resin complying with ISFA 2-01.

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

a. Avonite Surfaces; a Brand of Aristech Surfaces LLC.
b. DuPont; DuPont de Nemours, Inc.
c. Formica Corporation.
d. LG Hausys, Ltd.
e. Durat; CaraGreen LLC.

2. Integral Sink Bowls: Comply with CSA B45.5/IAPMO Z124.
3. Colors and Patterns: As selected by Architect from manufacturer's full range.

B. Particleboard: ANSI A208.1, Grade M-2.

C. Plywood: Exterior softwood plywood complying with DOC PS 1, Grade C-C Plugged, touch sanded.

## 2.2 FABRICATION

A. Fabricate countertops according to solid surface material manufacturer's written instructions and to the AWI/AWMAC/WI's "Architectural Woodwork Standards."

1. Grade: Premium.

B. Configuration:

1. Front: 1/8” Bevel Edge or Raised radius edge with apron, 2 inches (50 mm) high with 3/8-inch (9.5-mm) radius.
2. Backsplash: Straight, slightly eased at corner
3. End Splash: Matching backsplash
4. Side adjacent equipment: 1/8” Bevel Edge
5. Exposed Countertop Corner: 1” Radius Corner

C. Countertops:

1. 3/4-inch- (19-mm-) thick, solid surface material with front edge built up with same material.

D. Backsplashes: 1/2-inch- (12.7-mm-) thick, solid surface material.

E. Joints:
1. Fabricate countertops in sections for joining in field, with joints at locations indicated.

F. Cutouts and Holes:

1. Undercounter Plumbing Fixtures: Make cutouts for fixtures in shop using template or pattern furnished by fixture manufacturer. Form cutouts to smooth, even curves.

## 2.3 INSTALLATION MATERIALS

A. Adhesive: Product recommended by solid surface material manufacturer.

B. Sealant for Countertops: Comply with applicable requirements in Section 079200 "Joint Sealants."

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Fasten countertops by screwing through corner blocks of base units into underside of countertop. Predrill holes for screws as recommended by manufacturer.

B. Secure countertops to subtops with adhesive according to solid surface material manufacturer's written instructions. Shim as needed to align subtops in a level plane.

C. Bond joints with adhesive and draw tight as countertops are set. Mask areas of countertops adjacent to joints to prevent adhesive smears.

D. Install backsplashes and end splashes by adhering to wall and countertops with adhesive.

E. Install aprons to backing and countertops with adhesive.

F. Complete cutouts not finished in shop. Mask areas of countertops adjacent to cutouts to prevent damage while cutting. Make cutouts to accurately fit items to be installed, and at right angles to finished surfaces unless beveling is required for clearance. Ease edges slightly to prevent snipping.

G. Apply sealant to gaps at walls; comply with Section 079200 "Joint Sealants."

END OF SECTION 123661.16

SECTION 220500 – COMMON WORK FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SUMMARY

A. Requirements under this section include required work that is common to multiple sections in Division 22 and shall be complied with by all suppliers and subcontractors.

B. This Section includes the following:

1. Dielectric fittings.
2. Sleeves.
3. Escutcheons.
4. Grout.
5. Pipe Labels.
6. Fixture Supports.
7. Pipe hangers.

1.3 DEFINITIONS

A. A/E: Prime design consultant responsible for preparation of these specifications.

B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

G. The following are industry abbreviations for plastic materials:

1. ABS: Acrylonitrile-butadiene-styrene plastic.
2. CPVC: Chlorinated polyvinyl chloride plastic.
3. PE: Polyethylene plastic.
4. PVC: Polyvinyl chloride plastic.

H. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

## 1.4 SUBMITTALS

A. Provide submittals per Division 01, Section 013300, "Submittal Procedures."

B. Product Data: Submit product data for each type of product indicated herein. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Provide for the following:

1. Dielectric fittings.
2. Sleeves.
3. Escutcheons.
4. Grout.
5. Pipe Labels.
6. Fixture Supports.
7. Pipe Hangers

D. Operation and Maintenance Data:

1. All valves and specialty valves (Valve tag list),
2. Water piping system accessories, strainers, expansion tanks, meters, backflow preventers, gages, thermometers, trap primers, filters.
3. Drainage specialties, back water valves, drains, interceptors.
4. All equipment that includes an electrical connection and/or has recommended maintenance, along with all related accessories.
5. All controls.

## 1.5 QUALITY ASSURANCE

A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

B. 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.

C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

## 1.6 PROJECT CONDITIONS

A. Do not install products or materials that are wet, moisture damaged, or mold damaged.

B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect piping from end damage and to prevent debris from entering pipe. Maintain piping through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

## 1.8 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08, Section 083113, "Access Doors and Frames."

D. Coordinate work with other trades including venting, electrical connections, food Service, gas service, equipment connections, controls, etc.

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

F. Coordinate installation of identifying devices with locations of access panels and doors.

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

PART 2 - PRODUCTS

2.1 DIELECTRIC FITTINGS

A. Description: A combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Insulating Material: Suitable for system fluid, pressure, and temperature.

C. Dielectric Waterway Fittings:

1. Piping 2" Size and Smaller: Provide at each point of connection between copper and galvanized steel pipe, dielectric waterway design, threaded, lined with inert, non-corrosive thermoplastic.
2. Basis of Design: Clearflow Series 19100.
3. Manufacturers:

a. Clearflow.
b. Epco Sales, Inc.
c. Watts

D. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225-degree F. Calpico, Inc. or Lochinvar Corp "V-Line".

E. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225-degree F.

1. Manufacturers:

a. Precision Plumbing Products, Inc.
b. Sioux Chief,
c. Victaulic Corporation

2.2 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.

1. Underdeck Clamp: Clamping ring with set screws.

E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.

F. PVC Pipe: ASTM D 1785, Schedule 40.

G. Cast-in-place watertight device for protecting penetrating objects from expansion and contraction of concrete. Factory-assembled for use in cast-in-place concrete floors and walls and consisting of two outer sleeves and a one-piece radial extended-flange waterstop gasket, with mid-body seal for embedment and sealing to concrete slab and continuous water seal extending to the penetrating pipe.

1. Basis-of-Design Product: Subject to compliance with requirements, provide Hubbard Enterprises/HOLDRITE; Hydro Preseal, or a comparable product.
2. Outer Sleeves: EPDM attached to the mid-body seal forming an area with which to attach the device to the structural reinforcing rod determining the position of sleeve in the wall.
3. Water Stop Mid-body Seal: Flexible polymer seal with radial extended flange consisting of one to three concentric raised rings which lock into concrete, maintaining seal over time as concrete contracts from sleeve.

## 2.3 ESCUTCHEONS

A. General: Provide all steel manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening. All escutcheons shall have polished chrome plated finish. Provide deep pattern escutcheons where needed to conceal couplings and fittings that protrude beyond the wall surface. No split ring escutcheons, no plastic escutcheons.

## 2.4 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi, 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

## 2.5 IDENTIFICATION FOR PLUMBING PIPING

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

## 2.6 FIXTURE SUPPORTS

A. General: Fixture and equipment supports shall be compatible with plumbing fixture and equipment and chase width. Manufacturer: Zurn, Josam, Wade, Smith or Mifab.

B. Wall-Hung Urinal Supports: High-strength steel uprights with block bases for bolting to floor.

C. Electric Water Cooler Wall Supports: Floor-mounted fixture support, adjustable, heavy-duty steel plate and supporting studs. High-strength steel uprights shall have feet for bolting to floor.

D. Lavatory Supports: Floor-mounted support, concealed uprights, coated concealed arms with fixture locking device.

## 2.7 STEEL PIPE HANGERS AND EQUIPMENT SUPPORTS

A. Description: MSS SP-58-2009; **"**Pipe Hangers and support– Materials, Design, Manufacture, Selection, Application and Installation"**:** Types 1 through 59, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

1. Manufacturers:

   a. Anvil.
   b. B-Line Systems, Inc.
   c. ERICO/Michigan Hanger Co.
   d. Hubbard Enterprises/HOLDRITE®
   e. PHD Manufacturing, Inc.

B. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

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

## 2.8 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts. For piping 2" and below, manufactured specialty products formed from pre-galvanized commercial steel.

1. The total weight of piping and components upon each trapeze span shall not exceed the manufacturers load rating. Load ratings must include a minimum 2 X safety factor.

## 2.9 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

1. Manufacturers:

a. B-Line Systems, Inc.; a division of Cooper Industries.
b. ERICO/Michigan Hanger Co.; ERISTRUT Div.
c. Hubbard Enterprises/HOLDRITE®
d. PHD Manufacturing, Inc.
e. Unistrut Corp.; Tyco International, Ltd.

B. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

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

## 2.10 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

1. Manufacturers:

a. Carpenter & Paterson, Inc.
b. ERICO/Michigan Hanger Co.
c. Pipe Shields, Inc.

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

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

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

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

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

## 2.11 FASTENER SYSTEMS

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

1. Manufacturers:

a. Hilti, Inc.

b. Hubbard Enterprises/HOLDRITE®
c. ITW Ramset/Red Head.
d. Powers Fasteners.

## PART 3 - EXECUTION

### 3.1 PLUMBING DEMOLITION

A. Refer to Division 01, Section 017329, "Cutting and Patching" and Division 02, Section 024119, "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.

2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.

5. Equipment and Fixtures to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

### 3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated and/or code-required slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors where exposed to view from any location in a finished space and in stairways.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces. Exception: Extend sleeves installed in floors of mechanical equipment areas or other potentially wet areas two inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

    a. Steel Pipe Sleeves: For pipes smaller than NPS 6.
    b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
    c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two inches above finished floor level. Refer to Division 07, Section 076200, "Sheet Metal Flashing and Trim" for flashing.

3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for one-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

## 3.3 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

## 3.4 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping one to two-inch in size, adjacent to each valve (unless valve construction facilitates disassembly) and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in wet piping systems.

## 3.5 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel, and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

## 3.6 INSTALLATION OF PLUMBING FIXTURE AND EQUIPMENT CARRIER SUPPORTS

A. General: All fixtures shall be rigidly installed. Carriers shall have adjustable block base feet to permit vertical position of uprights regardless of uneven floor surface. Each carrier base shall be securely bolted to floor. Where 25-gauge steel framing is used for wallboard finish, provide additional structural bracing to ensure rigid installation of fixtures.

B. Wall Hung Urinal Supports: Supports shall be installed according to manufacturer's instructions. Where steel uprights are used, block bases shall be securely bolted to floor structure.

## 3.7 PIPE LABEL INSTALLATION

A. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Pipe color coding scheme shall be per the owner's standard.

C. Pipe painting and label color-coding shall be ANSI standards.

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

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

## 3.8 GROUTING

A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.

## 3.9 HANGER AND SUPPORT INSTALLATION

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

B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

   1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.

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 powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
   2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.

F. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.

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

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

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

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

K. Insulated Piping: Comply with the following:

   1. Attach clamps and spacers to piping.

      a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.

b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
c. Do not exceed pipe stress limits according to ASME B31.9 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.

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.

4. Shield Dimensions for Pipe: Not less than the following:

   a. NPS 1/4 to NPS 3-1/2 12 inches long and 0.048 inch thick.
   b. NPS 4 12 inches long and 0.06 inch thick.

5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

## 3.10 HANGER AND SUPPORT APPLICATIONS

A. Specific hanger and support requirements are specified 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. 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.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.
4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.

    a. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
    b. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
    c. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
    d. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
    e. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
    f. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
    g. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.

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

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

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

H. 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-joist construction to attach to top flange of structural shape.

3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:

    a. Light (MSS Type 31): 750 lb.
    b. Medium (MSS Type 32): 1500 lb.
    c. Heavy (MSS Type 33): 3000 lb.

13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.

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

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

J. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:

1. Horizontal (MSS Type 54): Mounted horizontally.
2. Vertical (MSS Type 55): Mounted vertically.
3. Trapeze (MSS Type 56): Two vertical type supports and one trapeze member.
4. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
5. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
6. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

7. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

## 3.11 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.

END OF SECTION 220500

SECTION 220700 – PLUMBING INSULATION 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. Section includes insulating the following plumbing piping services:

1. Domestic cold-water piping.
2. Domestic hot-water piping.
3. Domestic recirculating hot-water piping.

B. New Work: Completely insulate all new work as specified and scheduled.

C. Existing Work:

1. Insulate all existing piping where existing insulation is damaged, as if it is new piping.
2. Insulate all existing piping that is currently not insulated, as if it is new piping.

1.3 SUBMITTALS

A. Product Data: Submit for each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. Shop Drawings:

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per 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 and inspecting agency. Insulation shall have a flame spread index of 25 or less and smoke developed rating index of 50 or less.

B. Comply with the following applicable standards and other requirements specified for miscellaneous components:

1. Supply and Drain Protective Shielding Guards: ICC A117.1.

## 1.5 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22, Section 220500.

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment 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.

## 1.6 SCHEDULING

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

# PART 2 - PRODUCTS

## 2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 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.

## 2.2 PIPE INSULATION

A. Thermal Requirements for all Pipe Insulation: Insulation thickness and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

B. Glass Fiber Preformed Pipe Insulation: Glass fiber meeting ASTM C547, rigid molded. "K" value 0.23 at 75°F. Maximum service temperature shall not exceed 850°F. Jacket shall be high density, white Kraft bonded to aluminum foil for vapor barrier, reinforced with fiberglass yarn, permanently treated, secured with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples coated with vapor barrier mastic.

1. For interior use only. Do not use on exterior piping.
2. Approved Manufacturers:

a. Johns Manville "Micro-Lok HP."

b. Knauf Insulation "Earthwool 1000 Pipe Insulation."
c. Owens-Corning “Fiberglas SSLII-ASJ.”

3. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

a. Preformed Pipe Insulation: ASJ.

## 2.3 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

B. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

C. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

## 2.4 FIELD APPLIED JACKETS

1. Be careful to consider jacketing requirements for piping that may be outdoors, but not exposed to weather. Such piping may include piping in parking garages, within covered loading docks, etc. Make sure documents adequately address different requirements for different situations.

B. PVC Plastic: One-piece molded type fitting covers and jacketing material, gloss white. Connections, tacks, pressure sensitive color matching vinyl tape. PVC material shall be 25 flame spread and 50 smoke development rated per ASTM E-84.

1. Approved Manufacturers:

a. Johns Manville "Zeston 2000 PVC".
b. Proto Engineered Thermoplastcs Corp. "Proto Fitting Cover System".
c. P.I.C. Plastics, Inc.; FG Series.
d. Speedline Corporation "Smoke-Safe".

## 2.5 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement 100 to 1200 degree: Comply with ASTM C 449/C 449M.

## 2.6 ADHESIVES AND MASTICS

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. Obtain insulation and/or jacket manufacturer approval for all adhesives and mastics used. Obtain A/E approval for all locations where mastics will be used.

1. Adhesives shall not be considered an acceptable alternative to specified mechanical fastening methods without prior A/E approval.
2. All adhesives and mastics shall be suitable for the moisture conditions and temperatures that will be encountered.

B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

C. PVC Jacket Adhesive: Compatible with PVC jacket.

D. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
2. Service Temperature Range: Minus 20 to plus 180 deg F.
3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
4. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

## 2.7 SEALANTS

A. FSK and Metal Jacket Flashing Sealants: Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 200-degree F service temperature range. Color shall be aluminum or grey.

B. ASJ Flashing Sealants and Vinyl, PVDC, and PVC Jacket Flashing Sealants: Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 200-degree F service temperature range. Color shall be white.

## 2.8 TAPES

A. ASJ Tape: White, 3-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

B. FSK Tape: Foil-face, three-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

PART 3 - EXECUTION

3.1 MINIMUM INSULATION SCHEDULE

A. Fiberglass insulation shall not be used outdoors.

B. Domestic water pipe insulation:

C.

| Fluid Operating Temperature Range and Usage (F°) | Insulation Conductivity | | Nominal Pipe or Tube Size (Inches) | | | | |
|---|---|---|---|---|---|---|---|
| | Conductivity Btu·in./(h·ft²·°F) | Mean Rating Temperature, °F | < 1 | 1 to < 1 ½ | 1 ½ to ≤ 4 | 4 to < 8 | ≥ 8 |
| 105 – 140 | 0.21 – 0.28 | 100 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| 40 – 60 | 0.21 – 0.27 | 75 | 0.5 | 0.5 | 1.0 | 1.0 | 1.0 |

1. For piping smaller than 1 ½ inch and located in partitions within conditioned spaces, reduction of these thickness by 1 inch shall be permitted but not to a thickness less than 1 inch.

D. Service Schedule:

| System | Operating Temp. (°F) | Material |
|---|---|---|
| Domestic Cold Water | 40-60 | Glass-Fiber with ASJ |
| Domestic Hot Water,<br>Domestic Recirculating Hot Water | 105-140 | Glass-Fiber with ASJ |

E. All exposed piping shall be covered with PVC jacketing.

3.2 INSULATION WORK IN GENERAL

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 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 insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive as recommended by the insulation material manufacturer.

E. Install insulation with the least number of joints practical.

F. Install insulation with longitudinal seams at top and bottom of horizontal runs.

G. Do not apply insulation until the surfaces to be covered have been leak tested, have had rust and scale removed, and have been cleaned, dried, and inspected.

H. Insulation shall always be kept dry and clean.

I. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

J. 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.
5. Continue insulation vapor barrier through penetrations except where prohibited by code.

K. Continue pipe insulation through gypsum and masonry walls only if fire stopping specified in Division 07 has a UL Listed assembly that includes a jacketed insulation. Coordinate with General Contractor.

L. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
3. Overlap jacket longitudinal seams at least 1-1/2 inches. 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 o.c.
4. For below ambient services, apply vapor-barrier mastic over staples.
5. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
6. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

M. All work shall be performed at ambient and equivalent temperatures as recommended by the manufacturers.

N. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

O. Joints shall be staggered on multi-layer insulation.

## 3.3 INSULATION INSTALLATION, PIPING

A. General: Pipe insulation shall be installed in strict conformance to the manufacturer's recommendations. Pipe insulation shall be continuous and installed on all fittings and appurtenances unless specified otherwise. Installation shall be with full-length units of insulation and using a single-cut piece to complete a run. Provide jackets for all pipe insulation.

B. Insulation Installation on Straight Pipes and Tubes:

1. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
2. Secure laps with outward clinched staples at six inches o.c, for insulation with factory-applied jackets on above ambient surfaces.
3. Do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant, for insulation with factory-applied jackets on below-ambient surfaces.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.

D. Unions, Flanges, Couplings, Strainers, and Valves:

1. Insulate all fittings, flanges, couplings, strainers, valves (and similar accessories) associated with an insulated piping system unless indicated otherwise.
2. Exposed Work: On exposed work, insulate to a diameter equal to insulation of adjacent piping provided a minimum of 0.75" of insulation is maintained around fittings, couplings, strainers and valves, otherwise, increase diameter.
3. Concealed Work: On concealed work, increase insulation diameter to maintain same insulation thickness as on adjacent piping. Use same material as specified for adjacent piping; fitting covers to be as specified hereinafter.
4. Adjustable and Serviceable Valves and Accessories: Where balancing valves, strainers and similar devices are adjustable or require servicing on less than a five-year cycle, provide removable insulation sections. Where valves with repackable glands and similar devices allow service, but manufacturer does not anticipate service frequency to be less than five years, make reasonable provisions to allow removal and reinstallation of the same materials with minimal effort and potential for damage.

E. Insulation Support at Hangers:

1. Provide support shield and 360 degree insert between support shield and piping on piping 1-1/2" diameter and larger. Fabricate insert from heavy density insulating material suitable for the temperature. Shield shall be fabricated of 14-gauge galvanized sheet metal. Insulation shields and inserts shall be not less than the following lengths:

| | |
|---|---|
| 1/2" to 2-1/2" | 10" |
| 3" to 6" | 12" |

2. Vapor-barrier facing of the insert shall be of the same material as the facing on the adjacent insulation. Seal inserts into the insulation with lagging adhesive for vapor seal. Where anchors are secured to insulated chilled piping, insulate anchors same as piping for a distance not less than four times insulation thickness to prevent condensation.

F. Sleeves and Wall Chases: Insulation on pipes through walls and floors shall be full size and jacketed same as adjacent insulation.

G. Allowances for Movement: At points where pipe will move during expansion and contraction (expansion joints, Z-bends, expansion loops, etc.), clearances between the pipe and encased insulation shall be sized to permit full pipe movement without cracking or damaging insulation and casing or jacket.

## 3.4 FIELD-APPLIED JACKET INSTALLATION

A. General: Where field-applied jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with two-inch overlap at seams and joints.
2. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with two-inch 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 o.c. and at end joints.

END OF SECTION 220700

SECTION 221100 – WATER DISTRIBUTION 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. Section Includes:

1. Ball valves.
2. Mechanically coupled piping systems.
3. Water Hammer Arrestors.
4. Trap primers.
5. Thermostatic mixing valves.

B. Related Sections:

1. Division 22, Section 220500, "Common Work for Plumbing."

1.3 SUBMITTALS

A. Product Data: For the following products:

1. Ball valves.
2. Mechanically coupled piping systems.
3. Water Hammer Arrestors.
4. Trap primers.
5. Thermostatic mixing valves.

1.4 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF 61 for potable domestic water piping and components.

1.5 PROJECT CONDITIONS

A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Construction Manager in advance of proposed interruption of water service.

2. Do not proceed with interruption of water service without Construction Manager's written permission.

PART 2 - PRODUCTS

2.1 WATER PIPE AND FITTINGS (POTABLE AND NON-POTABLE WATER)

A. Pipe General:

1. Pipe Above Ground: Seamless copper water tube, ASTM B88, Type L, hard drawn.
2. Pipe Below Ground (3" Size and Smaller): Seamless copper water tube, ASTM B88, Type "K," annealed, ANSI/ASME B16.22 wrought copper fittings, joints made by soldering.

B. Fittings for Copper Tubing:

1. Wrought copper or bronze solder-joint pressure fittings conforming to ANSI/ASME B16.18 and ANSI/ASME B16.22.
2. Adapters may be used for connecting tubing to flanges and to threaded ends of valves and equipment.
3. Solder: Lead-free, silver bearing, NSF approved, for all joints in copper water tubing. Apply flux carefully and remove all excess.
4. Press Fittings: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-rings for copper press fittings shall be EPDM.

C. Unions, Copper Piping: 125-lb. wrought copper or cast bronze, solder joint type; ANSI/ASME B16.22 or ANSI/ASME B16.18.

D. Dielectric Fittings: See section 220500.

2.2 VALVES

A. General: Provide valves on all water piping systems (and pumped drainage piping systems), 125-psi system working pressure and below, where shown or specified. Provide valve in water or drain connection to each removable or replaceable item of equipment.

B. Shut-Off Valves 2" and Smaller: Ball type, bronze, lead free. Bronze shall be ASTM B584 Alloy C84400. Two-piece body style, threaded ends, full port, chrome plated solid brass ball, teflon seats, adjustable packing, lever handle, blowout proof stem, 150 wsp, 600 wog.

1. Approved Manufacturers:

a. Apollo No. 77CLF.
b. Milwaukee BA-400.
c. Nibco No. T-585-70
d. Red & White Valve Corp. 5044F
e. Watts No. B-6080

## 2.3 MECHANICALLY COUPLED PIPING SYSTEMS

A. Systems: Mechanically coupled piping products are approved for use on the following systems only: Domestic Potable and Non-Potable Cold-Water Systems, 2” size and larger.

B. Mechanically grooved pipe couplings, fittings, valves, and other grooved components may be used as an option to soldering, threading or flanged methods. All grooved components shall be of one manufacturer and shall conform to local codes and ordinances and ANSI/ASME B-31.1, B-31.9, UL/FM and IAPMO. The grooved product manufacturer shall be ISO-9001 certified. Manufacturer: Victaulic Company, Tyco-Grinnell or Anvil International Gruvlok.

C. Pipe and Fittings:

1. Copper tubing Type L, hard drawn, conforming to ASTM B88. The pipe shall be roll-grooved in accordance with the manufacturer's recommendations.
2. Copper Piping Fittings: Fittings shall be constructed of copper, per ASTM B75, alloy C12200 or B152 alloy C11000 or bronze sand cast per ASTM B-584, copper alloy CDA 836.
3. Fittings shall be grooved end fittings as designed in the manufacturer's catalog literature. Fittings shall be manufactured to copper tubing sizes, with grooves designed to accept grooved end couplings of the same manufacturer. Flaring of tube and fitting ends to IPS dimensions is not allowed.

D. Couplings and Components:

1. Coupling housings shall be ductile iron conforming to ASTM A395 and A536; cast and ductile iron and finished with copper alkyd enamel paint.
2. Bolts and nuts shall be carbon steel track type conforming to ASTM A183, minimum tensile 110,000 psi.
3. Gaskets in water piping system shall be Grade "E" EPDM, "FlushSeal®" style, with temperature range from -30°F to +230°F. (Gaskets UL classified in accordance with ANSI/NSF 61 for hot (+180°F) and cold (+80°F) potable water service.) Gasket selection for each system shall be in accordance with manufacturer's current recommendations to suit system pressure and temperature.
4. Adapters shall be used at flanged connections, engaging directly into roll grooved copper tube and fittings and bolting directly to ANSI
5. /ASME Class 125 and Class 150 flanged components, complete with standard flange bolts.

E. Dielectric Fittings: Dielectric fittings shall be used at piping connections between dissimilar metals and equipment to protect from local cell corrosion.

1. Approved Manufacturers:

   a. Anvil International Gruvlok "Di-Lok"
   b. Clearflow "Dielectric Waterway."
   c. Victaulic Corporation "Clearflow" Dielectric Waterway Style 47.

## 2.4 VALVES—MECHANICALLY COUPLED COPPER PIPING SYSTEMS

A. Butterfly Valves 2" through 4” Bronze body per ASTM B584 with EPDM encapsulated ductile iron disc, ductile iron per ASTM A536, stainless steel Type 416 upper and lower shafts, lever operated with 10-position throttling plate, manufacturer recommended for bi-directional dead end service at full rated pressure without a downstream flange, 300 psi cwp. Basis of Design: Grinnell Model B680.

B. Butterfly Valves 6" and Larger: Cast iron body, EPDM synthetic rubber encapsulated ductile iron disc with integrally cast stem, lever operated with 10-position throttling plate, manufacturer recommended for bi-directional dead end service at full rated pressure without a downstream flange, 300 psi cwp.

1. Approved Manufacturers:

a. Anvil Gruvlok Series 7600 or Series 7700.
b. Nibco No. GD-4765-3.
c. Victaulic Series 608.

## 2.5 WATER-HAMMER ARRESTERS

A. Water-Hammer Arresters:

1. Approved Manufacturers:

a. AMTROL, Inc.
b. Josam Company.
c. MIFAB, Inc.
d. Precision Plumbing Products, Inc.
e. Sioux Chief Manufacturing Company, Inc.
f. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
g. Tyler Pipe; Wade Div.
h. Watts Drainage Products.
i. Zurn Industries, LLC; Plumbing Products Group; Specification Drainage Products.

2. Standard: ASSE 1010 or PDI-WH 201.
3. Type**:** Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F, or PDI-WH 201, Sizes A through F.

## 2.6 TRAP PRIMERS

A. Mechanical Trap Primers-Intermittent Water Flow Type, TPV-X: Adjustable-type automatic trap seal primer valve, cast bronze body, 1/2" copper sweat connections or union connections. Manufacturer: Josam 88250, Wade Fig. W2400, Smith Fig. 2699 or Mifab MI-TSP-2.

B. Drainage-Type, Trap-Seal Primer Device TPV-X: ASSE 1044, lavatory P-trap with 3/8 minimum trap makeup connection, 1-1/4 trap size minimum, chrome plated cast brass. Zurn Z1021-WL; Jay R. Smith 2698-CAN.

C. Vacuum Breaker Type, Trap-Seal Primer Device TPV-X: Flush valve type with 3/8 minimum trap makeup connection, water deflector, vacuum breaker, chrome plated cast brass. Sloan VBF-72-A2, Precision Plumbing Products FVP-1VP.

## 2.7 THERMOSTATIC MIXING VALVES FOR LAVATORIES AND SINKS

A. Thermostatic Mixing Valve for Lavatories and Sinks, where indicated on plans: The thermostatic mixing valve shall control outlet temperature over a wide range of flow and shall be designed specifically for line control to wall-hung lavatories and sinks. Valve shall be bronze, brass, nylon and stainless steel construction. The valve shall employ a solid bimetal thermostat directly linked to valve porting to control the intake of hot and cold water. The adjustable high limit stop shall be set for 110°F. Operating pressure shall not exceed 125 psi. Valve shall have a screwdriver-adjustment temperature dial with scale: COLD-HOT. Check valves shall be provided in both hot water and cold water inlets. Valve shall have a vandal-resistant lockable handle to prevent tampering. Valve may be recessed in wall, located above accessible ceiling, or below the sink as long as it does not interfere with ADA clearances.

1. Approved Manufacturers:

   a. Acorn Controls
   b. Bradley
   c. Leonard
   d. Powers
   e. Symmons “Maxline” 7 Series.

B. Access Frame and Door: Provide a square frame with hinged locked door for access to the recessed thermostatic mixing valve. Frame and door shall be 16-gauge Type 304 stainless steel with No. 4 finish. Frame and door shall have concealed hinge and screwdriver operated latch. Nailer slots shall be provided for attaching to studs. In ceramic tile walls, provide with anchor straps. In plaster or wet wall construction, cover shall be flush with wall. Provide anchor holes when flushed cover is used. Door size shall be 8" x 8".

1. Approved Manufacturers:

   a. Bradley.
   b. Leonard.
   c. Powers.
   d. Jay R. Smith Fig. 4762 or Fig. 4767.

## 2.8 THERMOSTATIC MIXING VALVES FOR EMERGENCY EYEWASH FIXTURE

A. Thermostatic Mixing Valve for Emergency Eyewash Fixture: The thermostatic mixing valve shall control outlet temperature over a wide range of flow and shall be designed specifically for eyewash applications. The valve shall include a dial thermometer to measure the temperature of tempered stream. Temperature adjustment shall be vandal resistant. The control mechanism shall employ a liquid-filled thermostatic motor to drive the valve without additional power requirements. The control mechanism shall employ a stainless steel sliding piston control device with reverse seat closure and both fixed and variable cold water bypass. In the event of interruption of the hot water supply, each control mechanism shall allow cold flow through both the fixed and variable by-pass. In the event of interruption of the cold water supply, the control mechanism closes off the hot water port, stopping all flow. In the event the liquid motor fails, the control mechanism closed off the hot water port with the reverse seat and fully opens the internal variable bypass to allow cold water flow. Valve shall be bronze body. Valve assembly shall include lock set and mounting bracket. Inlet pressure shall not exceed 125 psi. Minimum supply pressure shall be 35 psi. Discharge temperature range shall be 70° to 90°F. Set point shall be 85°F.

1. Approved Manufacturers:

   a. Guardian Model G6040
   b. Lawler Model 911E.
   c. Leonard Series TA-350.
   d. Powers "Hydroguard Series Emergency Tempering Valve".
   e. Symmons.

# PART 3 - EXECUTION

## 3.1 PIPING JOINT CONSTRUCTION

A. Join pipe and fittings according to the following requirements and Division 22 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

   1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

## 3.2 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 1” and larger and 2" and smaller, adjacent to each valve and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in wet piping systems.

## 3.3 DOMESTIC WATER PIPING INSTALLATION

A. Special Requirements:

1. Protect stored pipes and tubes from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor, if stored inside.
2. Protect flanges, fittings, and piping specialties from moisture and dirt.

B. General Requirements:

1. Shutoff Valves: Install ball type shut-off valves at the base of each plumbing riser serving more than one fixture, in each branch line serving more than one fixture, and elsewhere as shown. Install valves in positions accessible for operation and repair.
2. Grading of Piping: Where possible, grade all lines to facilitate drainage. Provide drain valves at bottom of risers. All unnecessary traps in circulating lines shall be avoided. Connect branch lines at bottom of main serving fixtures below and pitch down so that main may be drained through fixture. Connect branch lines to top of main serving only fixtures located on floor above.
3. Concealed Piping: Conceal all piping in finished areas of the building unless noted otherwise.
4. All piping shall be run parallel with building construction and 90° angles to same.
5. Provisions for Piping Covering: Allow sufficient space for the proper installation of the pipe covering. If piping is installed too close to other piping or equipment, the piping shall be moved to avoid such interferences.
6. Pipe in Shafts: Piping in vertical shafts which are accessible shall be arranged to prevent obstruction to the access openings.
7. Install no piping of any kind in electrical equipment rooms, telephone equipment rooms, or elevator machine rooms.
8. Unions: Install at connections to all equipment downstream of valves, at all equipment specialties, and wherever else required to permit easy connection and disconnection. Do not conceal unions in walls, partitions, or inaccessible ceilings.
9. Dielectric Fittings: Provide approved dielectric type waterways, fittings, or flanges where pipe sections made of dissimilar metals are to be joined to prevent metal to metal contact. Do not use dielectric unions.

C. Connections to Fixtures:

1. General: Anchor supply connections at fixtures to steel straps secured to studs. At flush valves provide fitting with lugs secured to strap. At lavatories and other fixtures, secure piping directly to strap. Provide copper tubing stubs through wall for connection to compression type stops.
2. Contractor shall provide all necessary material and labor to connect to the plumbing system all fixtures and equipment having plumbing connections and which are furnished by the Owner or specified in other sections of these specifications.
3. The supply line to each item of equipment or fixture, except faucets, flush valves or other control valves which are supplied with an integral stop, shall be equipped with a shutoff valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures. Supply piping to all fixtures shall be anchored to prevent movement.
4. Partition-Type Stops: Provide on water supply to all fixtures which are not connected through individual exposed stops, integral stops, or stops in pipe space.
5. Electric Water Cooler Connections: Through a stop, 3/8" tubing supply, concealed within cabinet of cooler.

D. Water Hammer Arresters: Install on hot and cold-water piping, located close to each automatic faucet, control valve, flush valve, or any other type of quick closing valve or automatic valve, no exception. Sizing and placement shall conform to the requirements of PDI-WH201. Arresters shall be fully accessible.

E. Installation of Trap Primers: Install trap primers in strict compliance with the manufacturer's recommendations where readily accessible behind access doors or above accessible ceilings. Trap primer shall be located on domestic cold-water lines only. Do not prime shower drain traps.

F. Pressure Piping Regulations: All piping work, except drainage, shall conform to the "ANSI/ASME Building Services Piping Code," B31.9, including latest amendments.

G. Install water-hammer arresters in water piping according to PDI-WH 201.

H. Install trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting. Adjust valve for proper flow.

## 3.4 MECHANICALLY COUPLED PIPING JOINTS

A. Rolled grooved pipe for mechanically coupled joints shall be installed in accordance with the manufacturer's specifications contained in the latest published literature.

B. Fabrication techniques for all mechanical joints in accordance with manufacturer's recommendations contained in the latest published literature.

## 3.5 STERILIZATION OF DOMESTIC WATER PIPING

A. Provide disinfection and flushing of all new and altered or repaired potable water systems in accordance with "Disinfection of Potable Water System," Uniform Plumbing Code, 2021 Edition.

B. Sterilization and Flushing: All water piping, twenty-four (24) hour sterilization contact time, 50 parts per million chlorine concentration. Open all valves several times, following by flushing with clean water until residual chlorine is the same as that of potable water.

## 3.6 TESTING AND ADJUSTING

A. Water Piping: All domestic cold and hot water and non-potable water piping inside building shall be tested by hydrostatic pressure at 100 psi, for a minimum of 24 hours without any leaks. Provide a pressure gauge with a shutoff and bleeder valve at the highest point of the piping being tested. Only potable water shall be used for testing.

B. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION 221100

SECTION 221300 – SANITARY SEWERAGE 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. Section Includes: Work under this section includes:

1. Pipe, tube, and fittings.
2. Cleanouts.
3. Floor drains.
4. Miscellaneous sanitary drainage piping specialties.

B. Related Sections: Division 02, Section 220500, "Common Work for Plumbing."

1.3 DEFINITIONS

A. ABS: Acrylonitrile-butadiene-styrene plastic.

B. PVC: Polyvinyl chloride plastic.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Soil, Waste, and Vent Piping: 10-foot head of water.

B. Seismic Performance: Soil, waste, and vent piping and support and installation shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

1. Pipe, tube, and fittings.
2. Cleanouts.
3. Floor drains.
4. Miscellaneous sanitary drainage piping specialties.

## 1.6 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with NSF/ANSI 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping and "NSF-sewer" for plastic sewer piping.

## 1.7 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Waste Service: Do not interrupt service to facilities occupied by Owner or others unless permitted after arranging to provide temporary service.

# PART 2 - PRODUCTS

## 2.1 PIPING SCHEDULE

A. Aboveground, soil and waste piping shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings**;** heavy-duty hubless-piping couplings; and coupled joints.
2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

B. Aboveground, vent piping shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

C. Underground, soil, waste, and vent piping shall be any of the following:

1. Hubless, cast-iron soil pipe and fittings; heavy-duty hubless-piping couplings; and coupled joints.
2. Solid-wall ABS pipe, ABS socket fittings, and solvent-cemented joints.
3. Solid-wall PVC pipe, PVC socket fittings, and solvent-cemented joints.

D. Condensate Drain Piping: Condensate drain piping serving drain pans and cooling coil drain shall be ASTM B306 hard temper copper drainage tubing (DWV) with ANSI/ASME B16.23 cast bronze fittings.

## 2.2 CAST IRON SANITARY WASTE AND VENT PIPING

A. Standard of Quality: All cast iron sanitary, waste and vent piping shall bear the marking of Cast Iron Soil Pipe trademark and shall be manufactured in the United States. All the above products shall be listed with IAPMO under file numbers:

1. No. 2862 Couplings
2. No. 3209 Closet Bends
3. No. 3270 Cast Iron Soil Pipe and Fittings - No Hub and Service Weight.

## 2.3 HUBLESS, CAST-IRON SOIL PIPE AND FITTINGS

A. Pipe and Fittings: ASTM A 888 or CISPI 301.

B. Heavy-Duty, Hubless-Piping Couplings:

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. ANACO-Husky.
   b. Clamp-All Corp.
   c. MIFAB, Inc – Quick Hub
   d. Mission Rubber Company; a division of MCP Industries, Inc.
   e. Tyler Pipe.
   f. Ideal Tridon “Heavy-Duty” and “Super Heavy-Duty”.

2. Standards: ASTM C 1277 and ASTM C 1540.
3. Description: Type 304 stainless steel full shielded couplings having 2 stainless steel bands and tightening clamps for pipe sizes 1-1/2" through 4" and 4 stainless steel bands and tightening clamps for pipe sizes 5" through 10", and 6 stainless steel bands and tightening clamps for pipe sizes 12" through 15"; and ASTM C 564, rubber sleeve with integral, center pipe stop.

## 2.4 ABS PIPE AND FITTINGS

A. Solid-Wall ABS Pipe: ASTM D 2661, Schedule 40.

B. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.

C. Solvent Cement: ASTM D 2235.

1. ABS solvent cement shall have a VOC content of 325 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2. Solvent cement shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

## 2.5 PVC PIPE AND FITTINGS

A. Solid-Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.

B. PVC Socket Fittings: ASTM D 2665, made to ASTM D 3311, drain, waste, and vent patterns and to fit Schedule 40 pipe.

C. Adhesive Primer: ASTM F 656.

1. Adhesive primer shall have a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. Solvent Cement: ASTM D 2564.

1. PVC solvent cement shall have a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.6 CLEANOUTS

A. General Requirements for Cleanouts: Cleanouts shall be same size as the pipe, up to 4"; not less than 4" for larger pipe. Cleanouts shall be easily accessible. Provide a minimum clearance of 24 inches to facilitate rodding. Cleanouts shall be secured with vandal-proof screws.

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. Josam Company.
b. MIFAB, Inc.
c. Smith, Jay R. Mfg. Co.
d. Tyler Pipe.
e. Watts Drainage Products.
f. Zurn Plumbing Products Group.

B. Cleanouts in Floors: Floor cleanouts shall have cast iron body and frame with square adjustable scoriated secured nickel bronze top. Unit shall be vertically adjustable for a minimum of 2". When a waterproof membrane is used in the floor system, provide clamping collars on the cleanouts. Cleanouts shall consist of "Y" fittings and 1/8 bends with brass or bronze screw plugs. Cleanouts in resilient tile floors, quarry tile and ceramic tile floors shall be provided with square top covers recessed for tile insertion. In carpeted areas, provide carpet cleanout markers.

C. Cleanouts in Vertical Piping: Provide cleanouts at or near the base of the vertical stacks with the cleanout plug located approximately 24" above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. Extend the cleanouts to the wall access cover. Cleanouts shall consist of sanitary tees. Provide stainless steel or chrome plated cover with minimum opening of 6" x 6" at each wall cleanout.

D. Cleanouts in Horizontal Piping: In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked no-hub cast iron ferrule. Plain end (no-hub) piping in interstitial spaces or above ceiling may use plain end (no-hub) blind plug and clamp.

## 2.7 FLOOR DRAINS

A. General Requirements:

1. Unless otherwise specified, all drains shall have cast-iron bodies. Drain outlet size, as indicated on the drawings.
2. Drains shall generally consist of a body, integral seepage pan and adjustable perforated or slotted strainer consisting of grate and threaded collar. Drains shall be of double pattern suitable for embedding in the floor construction. The seepage pan shall have weep holes or channels to permit drainage from the pan to the drainpipe.
3. All drains shall be provided with trap primer connections, except shower drains. Each drain shall be provided with a P-trap and vent.
4. Drains with integral no-hub outlets are acceptable.
5. Drain Flanges and Clamps: All drains installed in slabs that are not slab-on-grade shall include drainage flanges. All drains in membrane floors shall include flange and membrane clamping ring.
6. Finishes: Strainers of drains in showers shall be chrome-plated bronze or polished-nickel bronze; strainers in all finished areas, including stairwells, temporary unfinished areas, etc., shall be polished-nickel bronze. Strainers and grates in unfinished areas, such as boiler rooms and mechanical equipment rooms, shall be galvanized cast-iron or chromate converted cadmium or zinc electroplated coating, unless otherwise specified.

B. Drains-General Type:

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. Josam Company.
   b. MIFAB, Inc.
   c. Smith, Jay R. Mfg. Co.
   d. Tyler Pipe.
   e. Watts Drainage Products.
   f. Wade.
   g. Zurn Plumbing Products Group.

2. Floor Drain-Showers: Cast-iron body, flashing collar with protector cap, 6" round chromium-plated bronze or polished nickel bronze adjustable strainer head. Manufacturer: Round top pattern, Zurn ZN-415, Josam 30000-6A, Smith Fig. 2010-A-NB, Wade No. 1100 STD-CP or approved Mifab. For square pattern head, Zurn ZN-415-S, Josam 30000-6S, Smith Fig. 2010-B, Wade 1100-GK or approved Mifab.

2.8 DRAINAGE SPECIALTIES:

A. Air Gaps: Air gaps shall be cast bronze construction. Provide polished chrome-plated finish where exposed to view. Manufacturer: Zurn Z-1025 or Zurn Z-1025 (-CP), Josam 88900-CP, Smith Fig. 3955 or 3955 (-CP) Series or approved Wade or Mifab.

B. Open Drains:

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast-iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

C. Floor-Drain, Trap-Seal Primer Fittings:

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 side inlet.

PART 3 - EXECUTION

3.1 INSTALLATION, BUILDING DRAINAGE AND VENT PIPING SYSTEMS

A. General: Comply with all local code and International Plumbing Code requirements for the installation of building drainage and vent piping unless otherwise indicated.

B. Installation of Floor and Roof Drains:

1. Floor drains and roof drains and shall be installed according to manufacturer's recommendations.
2. Drains with No-Hub outlets may be used. No-Hub couplings are specified in Part 2 of this Section.
3. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.

C. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:

1. Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
2. Locate at each change in direction of piping greater than 45 degrees.
3. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping.
4. Locate at base of each vertical soil and waste stack.

D. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.

E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.

F. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

1. Exception: Fitting may be omitted if trap has trap-seal primer connection.

3.2 CLEANING AND PROTECTION

A. Clean interior of piping. Remove dirt and debris as work progresses.

B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.

C. Place plugs in ends of uncompleted piping at end of day and when work stops.

## 3.3 TESTING AND ADJUSTING

A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.

1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.

B. Reinspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections, and arrange for reinspection.

C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.

D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping except outside leaders on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

E. Test of Drains: All floor drains, garage drains, planter drains, trench or area drains shall be flow tested to demonstrate proper operation. All traps and sumps shall be cleaned out.

END OF SECTION 221300

SECTION 223000 – PLUMBING 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. This Section includes the following:

1. Flow-control, electric, tankless, domestic-water heaters.

1.3 SUBMITTALS

A. Product Data: Submit for each type and size of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.

B. Provide for the following:

1. Domestic water heaters.

C. Shop Drawings: Diagram power, signal, and control wiring.

D. Domestic-Water Heater Labeling: Certified and labeled by testing agency acceptable to authorities having jurisdiction.

E. Operation and Maintenance Data: Include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain same type of water heaters 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 NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

D. UL Compliance: Fabricate and label water softeners to comply with UL 979, "Water Treatment Appliances."

E. UL Compliance: Comply with UL 778 for motor-operated water pumps.

## 1.5 COORDINATION

## 1.6 WARRANTY

A. Water Heater Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-fired, domestic-water heaters that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

    a. Structural failures including storage tank and supports.
    b. Faulty operation of controls.
    c. Deterioration of metals, metal finishes, and other materials beyond normal use.

2. Warranty Periods: From date of Substantial Completion.

    a. Electric, Tankless, Domestic-Water Heaters: Two years.

# 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 ELECTRIC, TANKLESS, DOMESTIC-WATER HEATERS

A. Flow-Control, Electric, Tankless, Domestic-Water Heaters:

1. (Available) Manufacturers:

    a. Bosch Water Heating.
    b. Chronomite Laboratories, Inc.
    c. Eemax, Inc.
    d. Stiebel Eltron

2. Standard: UL 499 for electric, tankless, domestic-water heater heating appliance.
3. Construction: Copper piping or tubing complying with NSF 61 barrier materials for potable water, without storage capacity.

    a. Connections: ASME B1.20.1 pipe thread.
    b. Pressure Rating: 150 psig (1035 kPa).
    c. Heating Element: Resistance heating system.
    d. Temperature Control: Flow-control fitting.
    e. Safety Control: High-temperature-limit cutoff device or system.

f. Jacket: Aluminum or steel with enameled finish or plastic.

4. Support: Bracket for wall mounting.

## PART 3 - EXECUTION

### 3.1 WATER HEATER INSTALLATION

A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

B. Install seismic restraints for water heaters. Anchor to substrate.

C. Install shutoff valves on cold-water-supply piping to water heaters and on hot-water outlet piping.

D. Install thermometer on outlet piping of water heaters.

### 3.2 WATER HEATER CONNECTIONS

A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.

C. Ground equipment according to Division 26, Section 260526, "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26, Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

E. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

F. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

### 3.3 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 223000

SECTION 224000 – PLUMBING FIXTURES

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 SUBMITTALS

A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow-control rates.

B. Operation and Maintenance Data:

1. Include plumbing fixtures in operation and maintenance manuals.
2. Refer to Division 01, Section 017800, “Closeout Submittals”.

1.3 MAINTENANCE MATERIAL 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. Faucet Cartridges and O-Rings: (3) of each type of cartridge and O-ring for each type of differing faucets installed.
2. Flushometer Repair Kits: (3) repair kits for each differing flushometer installed.

1.4 WATER EFFICIENCY STANDARDS

A. All applicable plumbing fixtures shall conform to the water efficiency standards set forth in Chapter 4 of the International Plumbing Code, latest adopted addition.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.

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. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities", Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act" for plumbing fixtures for people with disabilities.

D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.

E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.

F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

1.6 WARRANTY

A. Warranty Period for Commercial Applications: One year from date of Substantial Completion.

1.7 COORDINATION AND SCHEDULING

A. Coordinate delivery and installation of plumbing fixtures with other trades, such as flooring and cabinets, so as to have all materials on hand when needed for integrating fixtures and equipment into the construction.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All materials employed in permanent construction shall be new, full weight, in first class condition, and suitable for space provided.

B. All similar materials shall be of one manufacturer. Fixture trim for the entire job shall be supplied by the same manufacturer to the extent possible.

C. Fixtures and their trim shall be complete in every respect, including such items as escutcheons, hanger plates, bolts, supplies, stops, traps, etc.

D. All exposed metal parts of all fixtures, including faucets, waste fittings, indirect waste piping, waste plugs, strainers, flush valves, traps, supplies, and escutcheons shall be polished chrome-plated brass, unless otherwise specified including all parts within a base cabinet.

2.2 SYSTEM ACCESSORIES

A. Fixture Supports & Carriers: All fixture supports shall be ANSI approved to adequately support the fixture. Carrier shall best suit the fixture arrangement and wall space available for the piping arrangement and materials employed.

B. Cleanouts: Cast-iron wye, with brass, square head, screw-joint plug full size of piping. Acceptable Manufacturers: Josam, MIFAB, J. R. Smith, Wade, Zurn, or approved equal.

1. Walls: J. R. Smith Series 4472 with polished brass surface plate cover secured to plug by screw.
2. Floors and Concrete Surfaces: J. R. Smith Series 4111. Install where shown or required and accessible after completion of building.
3. Building Exterior: Standard cleanout for pipe material, Brooks precast concrete access box with cast iron top set flush in finish grade.

C. P-Traps: P-traps shall be connected to floor drains and where otherwise required or shown. Traps shall be constructed of coated cast-iron, or other materials as approved or noted on plans. Traps on floor drains shall be primed from the nearest water closet or approved priming valve.

D. Trap Primers: Provide trap primers on all floor drains and indirect receptors that do not serve plumbing fixtures. Primers shall be accessible and installed according to manufacturer's recommendations. Sioux Chief 695 series or Precision Plumbing Products P-1 and P-2 series. For kitchens and areas where multiple drains need to be primed, use Precision Plumbing Products PT series electronic trap priming manifolds.

E. Waste and all water supply piping for handicapped person fixtures shall be insulated with TrueBro Lav Guard or Plumberex Pro-Series kits, or approved equal.

F. Shower mixing valves to be T/P combination thermostatic and pressure balancing with limit stops to meet current codes. Shower valves by Leonard, Moen, Powers, Symmons, or approved equal.

## 2.3 FIXTURE CONNECTIONS

A. Fixture Stops: Fixture stops shall be by the primary plumbing fixture manufacturer (such as American Standard or Kohler) or a specialty manufacturing company such as Brass Craft or McGuire. Stops shall be chrome-plated with threaded or solder connection on the water supply inlet. Jam nuts are acceptable only on the fixture side of the stop. Stop handles shall be capable of manual operation – no tool or key required

B. Fixture Risers: Risers shall be braided stainless steel.

## 2.4 PLUMBING FIXTURES

A. Description: See Plumbing Fixture Schedule or notes on plans for fixture types and accessories.

B. Acceptable Manufacturers:

1. Fixtures: American Standard, Kohler, or approved equal.

   a. Water closets shall have a minimum MaP test rating of 1000 grams as determined by an independent agency.

2. Stainless Steel: Elkay, Just, or approved equal.
3. Fixture Trim:

a. Lav and Sink Faucets: Chicago Faucet, Kohler, Moen Commercial, Sloan, Symmons, T&S Brass, Zurn, or approved equal.
b. Flush Valves: Moen, Sloan Royal, Zurn AquaVantage, or approved equal.
c. Seats: primary fixture manufacturer or Bemis, Church, Olsonite, or approved equal.

4. Drainage Products: Josam, J. R. Smith, MIFAB, Sioux Chief Finish Line, Wade, Watts Drainage, Zurn, or approved equal.
5. Carriers: J. R. Smith, MIFAB, Watts Drainage, Zurn, or approved equal.
6. Shower valves: Acorn, Bradley, Moen Commercial, Symmons, or approved equal.
7. Emergency Fixtures: Acorn, Chicago Faucet, Encon, Haws, Guardian, Speakman, or approved equal.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.

B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.

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

### 3.2 INSTALLATION

A. All fixtures shall be installed to meet manufacturer's recommendations and local codes.

B. Unless otherwise noted, fixture rough-in shall be at heights shown within contract documents, or if not within contract documents, as recommended by manufacturer. Note special rough-in requirements for handicapped person fixtures.

C. An exposed stop valve shall be installed on each supply to each fixture connection. This includes such items as water fountains and rough-in provisions for ice makers, vending machines, etc. Stops shall be located in an accessible location behind or below the fixture serviced, otherwise in branch piping as approved.

D. Install fixtures complete with all necessary items such as carriers, plates, bolts, and escutcheons. Floor mounted fixtures shall have china bolt caps.

E. Escutcheons shall be installed on piping at all wall penetrations. Escutcheons shall seat tight to the wall.

F. All wall-hung fixtures shall be securely supported by a carrier or wall plate designed for the specific fixture and mounted tight to wall. The contractor shall provide adequate blocking, reinforcing and stiffening of plumbing wall to adequately support the fixture or wall support. Fixture installation which causes deflection of the wall will require reopening of the wall and re-support of the fixture. Wall hangers are not acceptable.

G. Set floor and roof drains in place, level and at proper elevation for drainage specified.

H. Use sealing compound Dow #784 white silicone sealant, or approved equal, for the following installations:

1. Rims and trim of stainless steel sinks and drop-in lavatories.
2. Between the wall and the outer edge of wall-hung water closets and urinals.
3. Between the wall and the adjoining edge(s) of mop sinks.
4. Between the floor and the bottom circumference of floor-mounted water closets.

I. Adjust faucets, operating hardware, and flush valves for specified flow. Test all tailpieces, traps, supplies, and faucets for leaks.

J. Verify and adjust hands-free faucets and flush valves to manufacturer's recommended sensitivity and time delay settings. Verify and adjust hands-free faucet supply water temperature to 105°F.

## 3.3 CLEANING

A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:

1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
2. Remove sediment and debris from drains.

B. After completing installation of exposed, factory-finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

## 3.4 PROTECTION

A. Provide protective covering for installed fixtures and fittings.

B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

C. During renovation work, do not leave inactive water piping full of water for more than two days without flushing or draining to reduce the accumulation of biofilm. Provide valves as required to isolate and drain piping left inactive for more than two days.

END OF SECTION 224000

SECTION 230500 – COMMON WORK RESULTS 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. Requirements under this section includes required work that is common to multiple sections in Division 23 and shall be complied with by all suppliers and subcontractors

1.3 DEFINITIONS

A. A/E: Prime design consultant responsible for preparation of these specifications.

B. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

C. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

D. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

E. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.

F. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

G. The following are industry abbreviations for plastic materials:

1. CPVC: Chlorinated polyvinyl chloride plastic.
2. PE: Polyethylene plastic.
3. PVC: Polyvinyl chloride plastic.

H. The following are industry abbreviations for rubber materials:

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

## 1.4 SUBMITTALS

A. Provide submittals per Division 01, Section 013300, “Submittal Procedures.”

B. Product Data: Submit product data for each type of product indicated herein. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Required in the following areas: Mechanical Rooms, Pump Rooms, shafts, and congested areas required for coordination. Include as a minimum all piping and ductwork.
2. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Wiring Diagrams: For power, signal, and control wiring.

D. Operation and Maintenance Data:

1. All valves and specialty valves (Valve tag list),
2. Piping system accessories including, but not limited to; strainers, expansion tanks, meters, gages, thermometers, traps, filters, etc.
3. Ductwork system accessories including, but not limited to; fire and smoke dampers, backdraft dampers, terminal units, etc.
4. All equipment that includes an electrical connection and/or has recommended maintenance, along with all related accessories.
5. All controls.

## 1.5 QUALITY ASSURANCE

A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."

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

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. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

D. 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.

E. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics (such as larger motor horsepower) may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

## 1.6 PROJECT CONDITIONS

A. Do not install products or materials that are wet, moisture damaged, or mold damaged.

B. Field Measurements: Verify actual dimensions of site conditions by field measurements before fabrication.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

## 1.8 TRANSITIONS AND OFFSETS BEYOND THE SCOPE OF WORK

A. Check drawings of other trades to verify spaces in which work will be installed. Establish exact locations of piping and ducts in such a manner as to conform to structure, avoid obstructions, and keep openings and passageways clear. Lines that must pitch, or that must have a constant elevation, shall have the right-of-way over lines not so restricted. Maintain maximum headroom. If space conditions appear inadequate, notify the A/E before proceeding with the work. Make reasonable modifications in the work without extra cost as needed to prevent conflict with work of other trades and for proper execution of the work.

B. If the total additional weight of sheet metal or piping materials (including associated fittings, hangers, seismic restraints and insulation) required for piping offsets which are not indicated or inferred on the contract documents exceeds nine percent (9%) of the total weight of the piping system, the amount exceeding this percentage may be considered to be beyond the requirements of these documents.

C. In order for additional compensation to be considered for transitions and offsets in excess of the amount stated in Paragraph B above, the Contractor shall submit to the A/E a detailed take-off of all materials indicated on the contract documents. The Contractor shall also submit a separate take-off along with coordination drawings or marked-up contract drawings with yellow highlighting indicating specifically the transitions and offsets considered to be "extra work." Additional compensation will only be considered if take-offs and drawings are received by the A/E four weeks in advance of the fabrication of conflicting work in the area of concern so that the A/E may be able to determine ways to minimize or eliminate the extra work.

1.9 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08.

PART 2 - PRODUCTS

2.1 STEEL PIPE HANGERS AND EQUIPMENT SUPPORTS

A. Description: MSS SP-58-2009; **"**Pipe Hangers and support– Materials, Design, Manufacture, Selection, Application and Installation"**:** Types 1 through 59, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" Article for where to use specific hanger and support types.

1. Basis of Design: Anvil.
2. Manufacturers:

a. Anvil.
b. B-Line Systems, Inc.
c. ERICO/Michigan Hanger Co.
d. Hubbard Enterprises/HOLDRITE®
e. PHD Manufacturing, Inc.

B. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.

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

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

2.2 TRAPEZE PIPE HANGERS

A. Description: MSS SP-58, Type 59, shop- or field-fabricated pipe-support assembly made from structural-steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts. For piping 2" and below, manufactured specialty products formed from pre-galvanized commercial steel.

1. The total weight of piping and components upon each trapeze span shall not exceed the manufacturers load rating. Load ratings must include a minimum 2 X safety factor.

a. Hubbard Enterprises/HOLDRITE EZ-Strut™ or owner approved equivalent.

## 2.3 METAL FRAMING SYSTEMS

A. Description: MFMA-3, shop- or field-fabricated pipe-support assembly made of steel channels and other components.

1. Basis of Design: Unistrut Corp.; Tyco International, Ltd.
2. Manufacturers:

    a. B-Line Systems, Inc.; a division of Cooper Industries.
    b. ERICO/Michigan Hanger Co.; ERISTRUT Div.
    c. Hubbard Enterprises/HOLDRITE®
    d. PHD Manufacturing, Inc.
    e. Unistrut Corp.; Tyco International, Ltd.

B. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.

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

## 2.4 THERMAL-HANGER SHIELD INSERTS

A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.

1. Basis of Design: Pipe Shields, Inc.
2. Manufacturers:

    a. Carpenter & Paterson, Inc.
    b. ERICO/Michigan Hanger Co.
    c. Pipe Shields, Inc.

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

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

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

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

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

## 2.5 FASTENER SYSTEMS

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

1. Basis of Design: Hilti, Inc.
2. Manufacturers:

    a. Hilti, Inc.
    b. Hubbard Enterprises/HOLDRITE®
    c. ITW Ramset/Red Head.
    d. Powers Fasteners.

## 2.6 PIPE STAND FABRICATION

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

1. Basis of Design: MIRO Industries
2. Manufacturers:

    a. ERICO/Michigan Hanger Co.
    b. MIRO Industries.

B. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.

1. Manufacturers:

    a. MIRO Industries.

C. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.

1. Basis of Design: MIRO Industries
2. Manufacturers:

    a. ERICO/Michigan Hanger Co.
    b. MIRO Industries.
    c. Portable Pipe Hangers.

3. Base: Stainless steel.
4. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
5. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

D. High-Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.

1. Manufacturers:

    a. Portable Pipe Hangers.

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.

E. Curb-Mounting-Type Pipe Stands: Shop- or field-fabricated pipe support made from structural-steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

## 2.7 PIPE POSITIONING SYSTEMS

A. Description: IAPMO PS 42, system of metal brackets, clips, and straps for positioning piping in pipe spaces for plumbing fixtures for commercial applications.

1. Basis of Design: HOLDRITE Corp.; Hubbard Enterprises.
2. Manufacturers:

a. C & S Mfg. Corp.
b. HOLDRITE Corp.; Hubbard Enterprises.
c. Samco Stamping, Inc.

## 2.8 EQUIPMENT SUPPORTS

A. Description: Welded, shop- or field-fabricated equipment support made from structural-steel shapes.

## 2.9 MISCELLANEOUS MATERIALS

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

B. Plenum Rated Pipe Clamps: ASTM E-84 25/50 plastic clamps from Hubbard Enterprises/ HOLDRITE.

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

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

## 2.10 EXPANSION COMPENSATORS

A. Flexible-Hose Expansion Joints: Manufactured assembly with two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose; with inlet and outlet elbow fittings, corrugated-metal inner hoses, and braided outer sheaths.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Metraflex Metraloop
    b. Flex-Hose Co., Inc.
    c. Flexicraft Industries.
    d. Flex-Pression, Ltd.

2. Flexible-Hose Expansion Joints for Copper Piping: Copper-alloy fittings with **solder** joint end connections.

    a. NPS 2 and Smaller: Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F and 340 psig at 450 deg F ratings.
    b. NPS 2-1/2 to NPS 4: Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F and 225 psig at 450 deg F ratings.

3. Flexible-Hose Expansion Joints for Steel Piping: Carbon-steel fittings with threaded end connections for NPS 2 and smaller and flanged end connections for NPS 2-1/2 and larger.

    a. NPS 2 and Smaller: Stainless-steel hoses and single-braid, stainless-steel sheaths with 450 psig at 70 deg F and 325 psig at 600 deg F ratings.
    b. NPS 2-1/2 to NPS 6: Stainless-steel hoses and single-braid, stainless-steel sheaths with 200 psig at 70 deg F and 145 psig at 600 deg F ratings.
    c. NPS 8 to NPS 12: Stainless-steel hoses and single-braid, stainless-steel sheaths with 125 psig at 70 deg F and 90 psig at 600 deg F ratings.

## 2.11 ALIGNMENT GUIDES

A. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

    a. Metraflex, Inc.
    b. Flex-Hose Co., Inc.
    c. Flexicraft Industries.
    d. Flex-Weld, Inc.
    e. Hyspan Precision Products, Inc.

## 2.12 MATERIALS FOR ANCHORS

A. Indicate alignment-guide length and maximum spider travel on Drawings.

B. Description: Steel, factory fabricated, with bolted two-section outer cylinder and base for alignment of piping and two-section guiding spider for bolting to pipe.

C. Steel Shapes and Plates: ASTM A 36/A 36M.

D. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head.

E. Washers: ASTM F 844, steel, plain, flat washers.

F. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, and tension and shear capacities appropriate for application.

1. Stud: Threaded, zinc-coated carbon steel.
2. Expansion Plug: Zinc-coated steel.
3. Washer and Nut: Zinc-coated steel.

G. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened Portland cement concrete, and tension and shear capacities appropriate for application.

1. Bonding Material: ASTM C 881, Type IV, Grade 3, 2-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
2. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated.
3. Washer and Nut: Zinc-coated steel.

H. Concrete: Portland cement mix, 3000 psi minimum. Comply with requirements in Division 03 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

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

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

## 2.13 THERMOMETERS

A. Manufacturer:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Marsh Bellofram/Marshalltown.
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Miljoco.

B. Thermometers: Adjustable angle, Direct-mounting, bimetallic-actuated dial thermometers complying with ASME B40.200.

1. Case: Highly polished, hermetically sealed, stainless steel with 5-inch diameter.
2. Element: Bimetal coil.
3. Dial: Satin-faced, or highly polished, non-reflective aluminum with permanently etched scale markings.
4. Window: Double strength Glass.

5. Connector: Adjustable angle, ½" with ASME B1.1 screw threads.
6. Stem: stainless steel, for thermo-well installation and of length to suit installation.
7. Accuracy: Plus or minus one percent of range or plus or minus one scale to maximum of 1.5 percent of range. Scale shall be degrees Fahrenheit, unless otherwise indicated, suitable for the media operating temperatures.
8. Thermometers shall conform generally to the following:

| SERVICE | RANGE – DEGREES F. | DEG. F/DIV. |
|---|---|---|
| Heating Hot Water | 30-240 | 2 |
| Condenser Water | 30-130 | 1 |
| Chilled Water | 0-100 | 1 |
| Steam and Condensate | 50 to 400 | 2 |
| Air Ducts | 40 to 120 | 1 |

C. Thermowells: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer with extension necks of suitable length for insulated piping. Furnished by same manufacturer as thermometers.

1. Threaded Stainless Steel
2. Pressure Rating – not less than piping system design pressure.
3. Stem Length – Extend 2" into fluid or to extend to center of pipe
4. Extension for insulated piping –2" nominal but not less than thickness of insulation
5. Threaded cap nut – With chain permanently fastened to well and cap.

## 2.14 PRESSURE GAUGES

A. Manufacturers:

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
2. Marsh Bellofram/Marshalltown
3. Trerice, H. O. Co.
4. Weiss Instruments, Inc.
5. Miljoco

B. Direct-Mounting, Dial-Type Pressure Gages:

1. Indicating-dial type complying with ASME B40.100.
2. Case: Liquid-filled type, 4-1/2-inch diameter Grade A phosphor Bronze.
3. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
4. Pressure Connection: Brass, NPS 1/4, bottom-outlet type unless back-outlet type is indicated.
5. Movement: Mechanical, with link to pressure element and connection to pointer.
6. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
7. Ring: Stainless steel.
8. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
9. Range for Fluids under Pressure: Two times operating pressure.
10. Scale: Scale shall be psig.

C. Shutoff Cocks for Gauges: 1/4" NPT lever handle ball valve with solid chrome-plated brass ball. Same manufacturer as gauge.

D. Pressure Snubbers: Filter type snubbing element, brass housing. Same manufacturer as gauge.

## 2.15 TEST PLUGS

A. Manufacturers

1. Peterson Equipment Co., Inc.
2. Sisco Manufacturing Co.
3. Or equal.

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem beyond insulation for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200-degree F.

D. Core Inserts: One or two self-sealing neoprene, valves gasketed orifice, suitable for inserting a 1/8” OD probe assembly.

1. Insert material for air, water, oil, or gas service at 20 to 200-degree F shall be CR.
2. Insert material for air or water service at minus 30 to plus 275-degree F shall be EPDM.
3. MeCHANICAL SLEEVE SEALS

E. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
2. Pressure Plates: Carbon steel. Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.
4. Basis of Design: Pipeline Seal and Insulator, Inc. "Thunderline Link Seal."
5. Manufacturers:

   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Pipeline Seal and Insulator, Inc.

## 2.16 SLEEVES

A. Galvanized-Steel Sheet: 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint.

B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

D. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing. Underdeck Clamp: Clamping ring with set screws.

E. PVC Pipe: ASTM D 1785, Schedule 40.

## 2.17 ESCUTCHEONS

A. General: manufactured wall and ceiling escutcheons and floor plates, with an id to closely fit around pipe, tube, and insulation of insulated piping and an od that completely covers opening.

B. One-piece, deep-pattern type (walls and ceilings): deep-drawn, box-shaped brass with chrome-plated finish.

C. One-piece, stamped-steel type (walls and ceilings): with set screw or spring clips and chrome-plated finish.

D. Split-plate, stamped-steel type: with concealed hinge, set screw or spring clips, and chrome-plated finish.

E. One-piece, floor-plate type: cast-iron floor plate.

F. Split-casting, floor-plate type: cast brass with concealed hinge and set screw.

## 2.18 GROUT

A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

1. Characteristics: Post-hardening, volume-adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
2. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
3. Packaging: Premixed and factory packaged.

# PART 3 - EXECUTION

## 3.1 DEMOLITION

A. Refer to Division 01, Section 017329, "Cutting and Patching" and Division 02, Section 024119, "Selective Structure Demolition" for general demolition requirements and procedures.

B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.

1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
2. Piping to Be Abandoned in Place: Only allowed where specifically shown on drawings. Drain piping and cap or plug piping with same or compatible piping material.
3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
4. Equipment to Be Removed: Disconnect and cap services and remove equipment.
5. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
6. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.

C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

## 3.2 PIPING SYSTEMS - COMMON REQUIREMENTS

A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated or, if conflicts exist, as indicated on Coordination Drawings.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. 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.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

F. Install piping to permit valve servicing.

G. Install piping at indicated and/or code-required slopes.

H. Install piping free of sags and bends.

I. Install fittings for changes in direction and branch connections.

J. Install piping to allow application of insulation.

K. Select system components with pressure rating equal to or greater than system operating pressure.

L. Install escutcheons for penetrations of walls, ceilings, and floors where exposed to view from any location in a finished space and in stairways, according to the following:

1. New Piping:

   a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
   b. Chrome-Plated Piping: One-piece, cast-brass type with polished chrome-plated finish.
   c. Other Piping: One-piece, stamped-steel type with spring clips.

2. Existing Piping: Same as for new piping.

M. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

1. Cut sleeves to length for mounting flush with both surfaces.

   a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other potentially wet areas two inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.

2. Install sleeves in new walls and slabs as new walls and slabs are constructed.

   a. **Steel** Pipe Sleeves: For pipes smaller than NPS 6.
   b. Steel Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
   c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to two inches above finished floor level. Refer to Division 07**,** Section 076200, "Sheet Metal Flashing and Trim" for flashing.

3. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for materials and installation.

N. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for one inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

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

P. Verify final equipment locations for roughing-in.

Q. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

## 3.3 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated:

1. Install unions, in piping NPS 2 and smaller, adjacent to each valve (unless valve construction facilitates disassembly) and at final connection to each piece of equipment.
2. Install flanges, in piping NPS 2-1/2 (DN 65) and larger, adjacent to flanged valves and at final connection to each piece of equipment.
3. Install dielectric coupling and nipple fittings to connect piping materials of dissimilar metals in piping systems.

## 3.4 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

D. Install equipment to allow right of way for piping installed at required slope.

## 3.5 HANGER AND SUPPORT APPLICATIONS

A. Comply with MSS SP-69 and 89 for pipe hanger selections and applications that are not specified otherwise in piping system Sections.

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

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

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

E. 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.
2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 degrees F pipes, NPS 4 to NPS 16, requiring up to 4 inches of insulation.
3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 requiring clamp flexibility and up to 4 inches of insulation.
4. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
5. U-Bolts (MSS Type 24): For support of heavy pipes.
6. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 and above, with steel pipe base stanchion support and cast-iron floor flange.
7. Single Pipe Rolls (MSS Type 41): For suspension of pipes, from 2 rods if longitudinal movement caused by expansion and contraction might occur.
8. Complete Pipe Rolls (MSS Type 44): For support of pipes if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.

F. 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.
2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers if longer ends are required for riser clamps.

G. 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-joist construction to attach to top flange of structural shape.
3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
6. C-Clamps (MSS Type 23): For structural shapes.
7. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod.
8. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.

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

1. Steel Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
3. Thermal-Hanger Shield Inserts: For supporting insulated pipe.

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

1. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
2. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
3. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.

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

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

L. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.

M. Trapeze Pipe Hanger Installation: Arrange for grouping of parallel runs of horizontal piping and support together on field-fabricated trapeze pipe hangers.

1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.

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

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

P. Equipment Support Installation: Fabricate from welded-structural-steel shapes.

Q. Select and locate 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.

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

S. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, 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.

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

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

V. Insulated Piping: Comply with the following:

1. Attach clamps and spacers to piping.

    a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    c. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.

2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
4. Shield Dimensions for Pipe: Not less than the following:

    a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
    b. NPS 4: 12 inches long and 0.06 inch thick.
    c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
    d. NPS 8 to 14: 24 inches long and 0.075 inch thick.

5. Insert Material: Length at least as long as protective shield.
6. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.

W. Do not use piping, ductwork, and equipment to support other piping, ductwork, equipment, or devices such as j-boxes and controls sensors. Provide independent supports. Do not drill holes, screws, or make similar penetrations into equipment such as sound attenuators and AHU casings.

## 3.6 PAINTING

A. Painting of HVAC systems, equipment, and components is specified in Division 09, Sections 099123, "Interior Painting" and 099113, "Exterior Painting."

B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

## 3.7 ERECTION OF METAL SUPPORTS AND ANCHORAGES

A. Refer to Division 05.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.

C. Field Welding: Comply with AWS D1.1.

## 3.8 GROUTING

A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.

## 3.9 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230500

SECTION 230540 – VIBRATION AND SEISMIC CONTROLS 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 EXTENT OF VIBRATION CONTROL WORK

A. Vibration Isolation: All equipment and piping as noted on the equipment, ductwork, and piping schedules in Part 3 of the specification shall be provided with vibration isolators to prevent the transmission of vibration and transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.

B. Pipe Riser Resilient Supports: Provide resilient support for all risers subject to significant expansion and/or contraction.

1.3 EXTENT OF SEISMIC CONTROL WORK

A. Seismic Restraints for New Construction: Provide professional structural engineering for seismic control of all new and relocated equipment, ductwork and piping specified in Division 23. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

B. Seismic Restraints for Remodeled Areas: Provide professional structural engineering for seismic control of all existing equipment, ductwork and piping that is normally provided under Division 23 and that will remain in place in areas where new ceilings are being provided as part of this project. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards.

C. Existing Construction: Provide professional structural engineering for seismic control of the existing equipment, ductwork and piping listed below that is not located within the remodeled areas. Provide all necessary seismic restraints to meet the requirements of the Code and referenced Standards

D. Omission of restraints for small components: Restraints may be omitted for smaller equipment, ductwork and piping only where specifically allowed by Code and referenced Standards, and where specifically allowed by the Qualified Professional Engineer (QPE) specified below. Restraints may only be omitted after the QPE has determined that adequate flexibility will be provided between restrained and non-restrained connected elements and determined that movement of unrestrained elements will not cause damage to adjacent elements.

1.4 DEFINITIONS

A. Code: 2021 International Building Code (IBC).

B. OSHPD: Office of Statewide Health Planning and Development for the State of California.

1.5 SEISMIC CONTROLS ENGINEERING REQUIREMENTS

A. Qualified Professional Engineer: Contractor shall provide the services of a qualified professional structural engineer to engineer, design and/or select anchorage methods for all equipment, ductwork and piping specified in this Division of the Specifications. This requirement applies to equipment, ductwork and piping that is supported from above or below and that is supported with vibration isolation or not.

1. A qualified professional engineer (QPE) familiar with all of the applicable codes and design standards related to seismic protection of HVAC ductwork, piping and equipment and qualified in structural design of seismic protections and their interaction with building structures shall be responsible for execution of the work herein. Where applicable, the QPE shall also analyze wind forces and shall utilize these forces (if greater than seismic forces) when designing component anchorages. The tasks of the QPE are as follows:

a. Shall be responsible for the preparation of drawings, analysis, specifications, and inspection of the seismic protections required by Code and referenced Standards.
b. Shall coordinate with the Structural Engineer of Record of the building structure for the proper establishment of seismic values, applicable codes, and other requirements of the project related to seismic and wind design.
c. Shall verify the applicability of all codes and design standards with the Authority Having Jurisdiction and shall coordinate with the Authority where codes conflict or are open for interpretation for variances and clarifications.
d. Shall inform the Contractor where special provisions in other work, such as routine hanger hardware selection, are required to accommodate seismic restraint. Changes from specified hanger hardware will require A/E prior approval and shall be provided without change in Contract cost.
e. Shall analyze specified and/or Contractor-proposed ductwork and piping materials along with associated joining methods for seismic-related strength (flexibility and/or “toughness”) and determine bracing spacing that will maintain appropriate integrity of the ductwork and piping during and after a design seismic event. If changes in construction are recommended in order to minimize the frequency of bracing, these shall be submitted for A/E review and will only be considered if a significant cost credit is offered.
f. Shall analyze specified and/or Contractor-proposed ductwork and piping materials along with associated joining methods for flexibility and determine the appropriate point bracing should stop along a specific run (when importance factor changes or when size reduces to a point where bracing may not be required).
g. Shall acquire equipment certifications for seismic worthiness from all equipment manufacturers where required by applicable codes or these specifications. These certifications shall be included in a final report to the Owner.
h. Shall perform calculations and select all required anchors and restraints.

i. Shall develop drawings (bearing QPE seal) of seismic controls that document the seismic anchors and restraints, their layout, and the details for their installation. Where design standards apply, the drawings shall note the locations and identify the standard details that apply.

2. The QPE shall be licensed to provide structural engineering in the project state.

B. Seismic-Restraint Loading: Engineering, selection and placement of seismic restraints shall be determined by the QPE after reviewing the project with the Structural Engineer of Record (for the building structure). Obtain all needed parameters directly from that engineer and clearly document these parameters within the submittals. For the purpose of pricing only, use the following values:

1. Site Class as Defined in the IBC: D.
2. Seismic Design Category: A
3. Risk Category: II
4. SDs: 0.04
5. SD1: 0.016

C. Components with Importance Factor Ip=1.5: Engineering, selection and placement of seismic restraints shall be determined by the QPE based on the following components having an Importance Factor of Ip=1.5:

1. Fuel source equipment and all sizes of piping.
2. Steam and condensate equipment and piping of all sizes.
3. All sizes of piping located in Electrical Rooms, Mechanical Rooms, Generator Rooms and Refrigeration Rooms. This applies to all kinds of piping, whether connected to equipment in those rooms or not.
4. Heating water equipment and piping greater than 2” size. Piping 2” in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than 2” size.
5. Chilled water equipment and piping greater than 2” size. Piping 2” in size and less that does not have a readily-accessible isolation valve separating it from any piping greater than 2” size.
6. All supply air equipment and ductwork upstream of terminal units.
7. Supply terminal units.
8. Supply ductwork downstream of terminal units greater than 3 square feet in area.
9. Isolation room exhaust equipment and ductwork of all sizes.
10. Return and exhaust equipment and ductwork greater than 3 square feet in area.
11. All other components required by Code to have an importance factor of Ip=1.5.

D. Components with Importance Factor Ip=1.0: All components not identified above as having an Importance Factor of Ip=1.5.:

## 1.6 RELATED WORK

A. Seismic Anchorage for Housekeeping Pads:

1. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be provided as part of this work, if not already adequate as indicated in the documents of other Divisions. This requirement applies only to pads that receive seismic forces for equipment anchored under this Section.
2. Housekeeping pads shall be coordinated by the seismic controls engineer to result in sizing such that a minimum edge distance of ten (10) bolt diameters is provided all around the outermost anchor bolts to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.
3. Provide restraint attachment plates cast into housekeeping pads, concrete inserts, double-sided beam clamps, etc., in accordance with the requirements of the manufacturer's calculations.

## 1.7 VIBRATION ISOLATION AND RISER SUPPORT SUBMITTALS

A. Product Data: For the following:

1. Vibration Isolators: Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Interlocking Snubbers: Include ratings for horizontal, vertical, and combined loads.

B. Construction Details and Calculations:

1. Riser Supports: Include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on building structure, spring deflection changes, and seismic loads. Include certification that riser system has been examined for excessive stress and that none will exist.
2. Vibration Isolation Base Details: Detail overall dimensions, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, base weights, equipment static loads, power transmission, component misalignment, and cantilever loads.

C. Operation and Maintenance Data.

## 1.8 SEISMIC CONTROL SUBMITTALS

A. Product Data: Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

1. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
2. Annotate to indicate application of each product submitted and compliance with requirements.

B. Construction Details and Calculations: For seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators, seismic restraints, and for designing vibration isolation bases.
2. Seismic-Restraint Details:

a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Operation and Maintenance Data.

## 1.9 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC and all local amendments unless requirements in this Section are more stringent.

B. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproved by ICC-ES, or preapproved by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

# PART 2 - PRODUCTS

## 2.1 FLEXIBLE PIPE CONNECTIONS

A. General: Flexible pipe connectors shall be provided at all piping connections to rotating equipment, isolated equipment and elsewhere as indicated.

1. Basis of Design: Mason Industries, Inc.,
2. Manufacturers:

a. Mason Industries, Inc.
b. Metraflex
c. Twin City Hose

d. Unisource Manufacturing

B. Flexible Spherical Expansion Joints: Flexible spherical expansion joints shall employ peroxide cured EPDM in the covers, liners, and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2" and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron and steel flanges with hooked or similar interlocks. Sizes 16" to 24" may be single sphere. Sizes ¾" to 1½" may have threaded bolted flange assemblies, one sphere and cable retention. ¼" and smaller connectors shall be rated at 250 psi up to 190°F with a uniform drop in allowable pressure to 190 psi at 250°F. 16" and larger connectors are rated 180 psi at 190°F and 135 psi at 250°F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5-minute factory test at twice the rated pressure. Concentric reducers to the above specifications many be substituted for equal ended expansion joints. Expansion joints shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have ½" thick Neoprene washer bushings large enough in area to take the thrust at 1,000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves. Submittals shall include two test reports by independent consultants showing minimum reductions of 20dB in vibration accelerations and 10dB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Manufacturer shall verify materials are compatible with glycol or other chemicals to be utilized in the piping system.

1. Manufacturer: Mason Industries, Inc., Type "SAFEFLEX SFDEJ, SFEJ, SFDCR, or SFU" with Type "CR" control rods.

C. Flexible Stainless-Steel Hose: Flexible stainless-steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3" and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

| Flanged | | Male Nipples | |
|---|---|---|---|
| 3 x 14 | 10 x 26 | ½ x9 | 1 ½ x 13 |
| 4 x 15 | 12 x 28 | ¾ x10 | 2 x 14 |
| 5 x 19 | 14 x 30 | 1x11 | 2 ½ x18 |
| 6 x 20 | 16 x 32 | 1 1/4 x 12 | |
| 8 x 22 | | | |

D. Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible.

1. Manufacturer: Mason Industries, Inc., Type "BSS."
2. Metraflex
3. Unisource Manufacturing

## 2.2 VIBRATION ISOLATORS

A. General: Provide complete, engineered vibration-isolation systems. Engineering support shall be provided by a representative of the manufacturer and shall be in full compliance with the manufacturer's recommendations and the following requirements.

1. Basis of Design: Mason Industries, Inc., utilizing the products specified in the following paragraphs.
2. Manufacturers:

   a. California Dynamics Corporation.
   b. Kinetics Noise Control.
   c. Mason Industries, Inc.
   d. Vibro-Acoustics.

B. General Requirements:

1. Isolator Identification: All vibration isolators shall be clearly marked to show undeflected heights so that after installation and adjustment, deflection under load can be verified, thus determining that the load is within the proper range of the device and that the correct degree of vibration isolation is being attained.
2. Provide a balanced set of isolators for each piece of equipment. Select isolators in accordance with equipment weight distribution to allow for no less than static deflection specified. All isolators for a single piece of equipment shall have approximately equal spring deflection. A minimum of four isolators per unit is required unless otherwise indicated.
3. Each isolator shall be numbered and color-coded to show location. Code number and color shall be marked on plans, on each equipment isolator, and on each base to ensure proper placement.
4. Operating Limits: All isolators shall operate in the linear portion of their load versus deflection curve. Load versus deflection curves shall be furnished by the manufacturer and must be linear over a deflection range of not less than 50% above the design deflection.
5. The spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load.
6. The theoretical vertical natural frequency for each support point, based upon the load per isolator and isolator stiffness, shall not differ from the design objectives for the equipment as a whole by more than ±10%.
7. Neoprene Mountings: All neoprene mountings shall have a shore hardness of 40–65 after minimum aging of 20 days, or corresponding oven-aging.
8. Neoprene Isolator Formulation: Formulation of the neoprene shall conform to AASHTO specifications for neoprene or ASTM D4014 specification for elastomer:
9. All vibration isolation hardware shall be designed or treated for corrosion resistance. Isolators exposed to the weather shall have steel parts zinc electroplated, PVC coated, plus a coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial grade enamel. Nuts, bolts, and washers shall be zinc electroplated.

C. Isolator Type 1: Two layers of ¾" thick neoprene pad consisting of 2" square waffle modules separated horizontally by a 16-gauge galvanized shim. Load distribution plates shall be used as required. Basis of Design: Mason Industries, Inc., Type Super "W."

D. Isolator Type 2: Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2" and all directional seismic capability. The mount shall consist of a ductile iron casting containing two separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing specifications. Mountings shall have an Anchorage Preapproval "OPA" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type Super "BR."

E. Isolator Type 3: Spring isolators shall be freestanding and laterally stable without any housing and complete with a molded neoprene cup or ¼" neoprene acoustical friction pad between the baseplate and the support. Basis of Design: Mason Industries, Inc. Type "SLF."

F. Isolator Type 4: Restrained spring mountings shall have an SLF mounting as described in Type 3, within a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½" shall be maintained around restraining bolts and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position, there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval "OPA" Number from OSHPD in the State of California certifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type "SLR."

G. Isolator Type 5: Spring mountings built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼" travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval "OPA" number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Basis of Design: Mason Industries, Inc., Type " SSLFH."

H. Isolator Type 6: Hangers shall consist of rigid steel frames containing minimum 1¼" thick neoprene elements at the top and a steel spring seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability, the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Basis of Design: Mason Industries, Inc., Type "30N."

I. Isolator Type 7: Hangers to be pre-compressed and locked at the rated deflection by means of a resilient seismic up-stop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a drawing of the hanger showing the 30° capability. Basis of Design: Mason Industries, Inc., Type "PC30N."

## 2.3 VIBRATION ISOLATION EQUIPMENT BASES

A. Manufacturers: Provide complete, engineered equipment bases. Engineering support shall be provided by a representative of the manufacturer and shall be in full compliance with the manufacturer's recommendations and the following requirements.

1. Basis of Design: Factory-fabricated products by Mason Industries, Inc.
2. Manufacturers:

    a. California Dynamics Corporation.
    b. Kinetics Noise Control.
    c. Mason Industries, Inc.
    d. Vibro-Acoustics.

B. Type B-1 Base: Steel Base, factory-fabricated, welded, structural-steel bases and rails.

1. Design Requirements: Lowest possible mounting height with not less than 1-1/2-inches clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
2. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
3. Cross members shall be provided where necessary to support the equipment or to prevent twisting of the main members. The section depth of any frame member shall be not less than 1/10th of the length of the longest frame member and not less than 1/10th of the greatest span between support points. All frame members shall have the same depth.
4. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

C. Type B-2 Base: A welded structural steel base constructed of angle iron or channels, designed to spread base area of equipment to increase stability and permit suspension with hanger rods.

D. Type B-3 Base: Inertia Base, factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.

1. Design Requirements: Lowest possible mounting height with not less than 1-inch clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
2. Base shall consist of a perimeter welded structural steel pouring form, 1/2" diameter reinforcing bars welded in place on 6" centers each way, pre-located equipment anchor bolts and pipe sleeves, and isolator brackets to reduce the mounting height of the equipment. The bottom edge of the steel reinforcing bars shall be 1-1/2" from bottom of the base. Drilled steel members shall have sleeves below the holes to receive anchor bolts. Thickness of the base shall be a minimum depth of 1/12th of the longest span, but not less than 6" deep. The base shall be sized a minimum overlap of 4" around the base of the equipment, and in the case of belt-driven equipment, 4" beyond the end of the drive shaft.
3. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
4. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.

5. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.

## 2.4 VERTICAL RISER SUPPORTS

A. General: Provide complete engineered pipe riser support systems. Engineering support shall be provided by a representative of the manufacturer and shall be in full compliance with the manufacturer's recommendations and the following requirements. Submittal must be stamped and signed by a licensed professional engineer in the employ of the manufacturer.

1. Basis of Design: Mason Industries, Inc., utilizing the following products:

   a. Support spring mountings; SLF
   b. Anchors; ADA.
   c. Telescoping guides; VSG

2. Manufacturers:

   a. California Dynamics Corporation.
   b. Kinetics Noise Control.
   c. Mason Industries, Inc.

B. Riser Supports: All vertical risers for systems with an operating temperature greater than 105 degrees F. and a height greater than 60 feet, or an operating temperature greater than 200 degrees F. and a height greater than 40 feet, shall be supported by spring isolators designed to support the riser filled with water. Risers that do not fall in these categories may utilize other means of support that will not result in more than 50% variation of force on any point of support under any operating condition.

1. Riser anchors close to the center of the run shall direct movement up and down. The anchors shall be capable of holding an upward force equal to the water weight when the system is drained. Obtain the maximum allowed point loading from the building structural engineer of record. If one level cannot accommodate the anticipated force, anchors can be located on two or three adjacent floors.
2. Steam Risers: If the riser is a steam riser, the design weight should not include water, except the isolators shall not be damaged if the pipe is filled with water. Assigned loads must be within the building design limits at the support points.
3. Long Risers: Provide support spring mountings at levels above and below the anchor level(s) when loading at the anchor level(s) would otherwise exceed the recommendations of the anchor manufacturer, maximum floor loading or would result in an unreasonable stress in the piping system itself.
4. The initial spring deflection shall be a minimum of 0.75"(20mm) or four times the thermal movement at the isolator location, whichever is greater. Calculations shall include pipe stress at end conditions and branch off locations and the manufacturer must include installation instructions.

C. Riser Guides: Provide telescoping guides where needed to maintain riser alignment. Resilient guides shall be spaced and sized properly depending on the pipe diameter. Submittals must include the initial load, initial deflection, change in deflection, final load and change in load at all spring and anchor support locations, as well as guide spacing. Proper provision shall be made for seismic protection as directed by the Seismic QPE.

D. Coordination at top and bottom of risers: Riser support manufacturer's engineer shall direct the Contractor on special provisions needed for support and routing of horizontal piping that is connected to the top, bottom and at various midpoints of each riser. Provide additional spring hangers and similar provisions for horizontal piping as required to avoid unreasonable stress on piping and supporting elements.

## 2.5 SEISMIC-RESTRAINT COMPONENTS

A. Manufacturers:

1. Basis of Design: Pre-approved products where available from Mason Industries, Inc., custom designed products where not available from Mason Industries, Inc.
2. Manufacturers:

   a. International Seismic Application Technology (ISAT).
   b. Kinetics Noise Control.
   c. Mason Industries, Inc.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES or OSHPD.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Seismic Cable Restraints consisting of galvanized steel aircraft cables shall be provided for vibration-isolated components.
3. Seismic Solid Braces consisting of steel angles or channels shall be provided for all suspended components that are not vibration isolated.
4. Pipe clevis cross bolt braces are required in all restraint locations
5. Provide hanger rod reinforcing to prevent buckling due to upward forces caused by restraints.

C. Base-mounted equipment with vibration isolation: Where integral seismic restraints furnished with vibration isolators are not adequate, provide all-directional seismic snubbers consisting of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene.

D. Restraint Anchors: Provide appropriate anchors to attach equipment, seismic restraints, and vibration isolation devices (if being used for seismic restraint), to the building structure. The method of connection to the structure shall be identified at each location on the Layout Drawings. All components shall meet the requirements of the authorities having jurisdiction. Where available, anchors (such as wedge anchors) shall have an evaluation report number from the ICBO Evaluation Service, Inc. verifying its allowable loads

## 2.6 FACTORY FINISHES

A. All vibration isolation and seismic restraint hardware shall be designed or treated for corrosion resistance.

B. Items exposed to the weather shall have steel parts zinc electroplated, PVC coated, plus a coating of neoprene or bitumastic paint. Aluminum components for outdoor installation shall be etched and painted with industrial enamel.

C. Nuts, bolts, and washers shall be zinc electroplated.

D. Structural steel bases shall be thoroughly cleaned of welding slag, primed with zinc chromate, and finished with two coats of industrial enamel.

E. Field painting shall comply with requirements in Division 09. Verify compatibility of factory finishes with field-applied coats.

# PART 3 - EXECUTION

## 3.1 VIBRATION ISOLATION INSTALLATION REQUIREMENTS

A. Vibration Isolation for Piping:

1. When piping connects to equipment is provided with vibration isolation and a flexible connection is not provided at the equipment, the first four pipe hangers shall be Type 7 with the same deflection as specified for the mountings under the connected equipment.
2. Floor supported piping shall be isolated with Type 4 isolators.
3. Do not support vibration isolated piping along with non-isolated piping on a common trapeze.
4. Steel spring hanger boxes shall be rigidly mounted to the supporting structure-not located in the middle of the hanger rod.
5. Hanger rods shall be aligned to clear the hanger box.
6. Load-transfer isolators, when utilized, shall temporarily maintain the piping in a rigid position until installation is complete and fully loaded.
7. Pipe anchors are not permitted in vibration isolated piping circuits.

B. General Requirements for Equipment Bases:

1. All bases shall be installed on housekeeping pads. All bases shall be sized to include equipment and motor without overhang.
2. Motor-driven equipment shall be mounted with motors on a common base of sufficient rigidity to maintain permanent alignment.
3. All bases shall have clearance of 1-1/2" between top of floor and underside of base.
4. Inertia bases shall have 1-1/2" clearance for first 50-sq.ft. of area.

## 3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION REQUIREMENTS

A. Install seismic restraints for all equipment and all sizes of ductwork and piping except where omission of restraints for smaller sizes is specifically allowed by Code and specifically allowed by the QPE and seismic restraint manufacture's guidelines.

B. Install cables so they do not bend across edges of adjacent equipment or building structure.

C. Hanger Rod Stiffeners: Install hanger rod stiffeners where required to prevent buckling of hanger rods due to seismic forces.

D. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.

E. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

G. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

## 3.3 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Prepare test and inspection reports.

## 3.4 ADJUSTING

A. Adjust isolators after piping system is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230540

SECTION 230550 – IDENTIFICATION FOR PIPING AND EQUIPMENT

## 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 SUBMITTALS

A. Product Data: Submit for each type of product indicated.

B. Valve numbering scheme.

C. Valve Schedules: For each piping system to include in maintenance manuals.

## 1.3 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, 1/8-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-degree 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.

## 2.2 PIPE LABELS

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

B. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.

C. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.

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

1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
2. Lettering Size: As appropriate for pipe size.

## 2.3 VALVE TAGS

A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.

1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Fasteners: Brass beaded chain; or S-hook.

B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses. Valve-tag schedule shall be included in operation and maintenance data.

# PART 3 - EXECUTION

## 3.1 PREPARATION

A. Clean piping and 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.

## 3.3 PIPE LABEL INSTALLATION

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

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

## 3.4 VALVE-TAG INSTALLATION

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

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230550

SECTION 230590 – 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 01 specification sections, apply to this section.

B. Division 23, Section 230500 is directly related. Other sections are indirectly related and shall be reviewed.

1.2 SUMMARY

A. Work under this section shall include furnishing all labor, materials, tools, and equipment necessary for testing, adjusting, and balancing (TAB) necessary to place all systems and items of equipment, specified in Division 23, in proper operating condition. All work shall be completely tested as required by this section and applicable city, county, and state codes and ordinances.

B. Submit copies of all testing, adjusting, and balancing data to A/E.

C. Leak and pressure testing of piping and duct systems and rotational testing of motors shall be performed by the installing contractor.

D. TAB shall include the following:

1. Air Systems:

   a. Constant-volume air systems.
   b. Variable-air-volume systems.

2. Hydronic Piping Systems:

   a. Primary-secondary systems.

3. Steam systems.
4. HVAC equipment quantitative-performance settings.
5. Laboratory fume hood airflow balancing.
6. Exhaust hood airflow balancing.
7. Space pressurization testing and adjusting.
8. Verifying that automatic control devices are functioning properly.
9. 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. Air Systems: Includes all outside air, supply air, return air, transfer air, exhaust air, relief air and make-up air systems.

C. Balance: To proportion flows within the distribution system, including submains, branches, and terminals, according to indicated quantities.

D. 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.

E. 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.

F. Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

G. Hydronic Systems: Includes chilled water, condenser water, heating hot water, and glycol-water systems, and heat recovery water systems.

H. Procedure: An approach to and execution of a sequence of work operations to yield repeatable results.

I. RC: Room criteria.

J. Report Forms: Test data sheets for recording test data in logical order.

K. Smoke-Control System: An engineered system that uses fans to produce airflow and pressure differences across barriers to limit smoke movement.

L. Smoke-Control Zone: A space within a building that is enclosed by smoke barriers and is a part of a zoned smoke-control system.

M. Stair Pressurization System: A type of smoke-control system that is intended to positively pressurize stair towers with outdoor air by using fans to keep smoke from contaminating the stair towers during an alarm condition.

N. 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.

O. Suction Head: The height of fluid surface above the centerline of the pump on the suction side.

P. System Effect: A phenomenon that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.

Q. 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.

R. TAB: Testing, adjusting, and balancing.

S. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

T. Terminal Unit: A device that controls the temperature and/or volume of air that enters or leaves a zone.

U. Test: A procedure to determine quantitative performance of systems or equipment.

V. Testing, Adjusting, and Balancing (TAB) Firm: The entity responsible for performing and reporting TAB procedures.

W. Zone: The space that is controlled by a terminal unit or other temperature controlling device.

## 1.4 SUBMITTALS

A. Qualification Data: Within 30 days from Contractor's Notice to Proceed, submit two copies of evidence that TAB firm and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Certified TAB Reports: Submit two copies of reports prepared, as specified in this Section, on approved forms certified by TAB firm.

C. Warranties specified in this Section.

## 1.5 QUALITY ASSURANCE

A. Contracting: The TAB agency shall be a subcontractor of the General Contractor and shall report to and be paid by the General Contractor.

B. TAB Firm Qualifications:

1. The TAB agency shall be either a certified member of AABC or certified by the NEBB to perform TAB service for HVAC, water balancing and vibrations and sound testing of equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify the A/E and submit another TAB firm for approval. Any agency that has been the subject of disciplinary action by either the AABC or the NEBB within the five years preceding Contract Award shall not be eligible to perform any work related to the TAB. All work performed in this Section and in other related Sections by the TAB agency shall be considered invalid if the TAB agency loses its certification prior to Contract completion, and the successor agency’s review shows unsatisfactory work performed by the predecessor agency.
2. TAB Specialist: The TAB specialist shall be either a member of AABC or an experienced technician of the Agency certified by NEBB. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the Specialist loses subject certification during this period, the General Contractor shall immediately notify the A/E and submit another TAB Specialist for approval.
3. TAB Specialist Responsibilities:

a. The General Contractor, within 60 days after the notice to proceed, shall identify TAB specialist who would be responsible for supervising, coordinating, scheduling and reporting all TAB work and related activities and provide necessary information as required by the A/E.
b. All TAB work shall be performed under the direct supervision of the TAB specialist.
c. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC or NEBB. The reports shall be signed by the TAB specialist and shall bear the seal of the TAB standard.
d. The TAB Specialist would follow all TAB work through its satisfactory completion.
e. Final markings of settings of all HVAC adjustment devices.
f. Permanently mark location of duct test ports.

4. All TAB technicians performing actual TAB work shall be experienced and must have done satisfactory work on a minimum of three projects comparable in size and complexity of this project and must be certified so by the TAB agency in writing.

C. Test Equipment Criteria: The basic instrumentation requirements and accuracy/calibration required by AABC, National Standards or by NEBB Procedural Standards for Testing, Adjusting and Balancing of Environmental Systems and instrument manufacturer. Provide calibration history of the instruments to be used for test and balance purpose.

1. Instrumentation Calibration: Calibrate instruments at least every year or more frequently if required by instrument manufacturer.
2. Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

D. Tab Criteria and Tolerances:

1. One or more of the applicable AABC or NEBB publications, supplemented by ASHRAE Handbook "2019 HVAC Applications" Chapter 39, and requirements stated herein shall be the basis for planning, procedures, and reports.
2. Flow rate tolerance: Following tolerances are allowed. For tolerances not mentioned herein follow ASHRAE Handbook "2019 HVAC Applications", Chapter 39 as a guideline. Air Filter resistance during tests, artificially imposed if necessary, shall be at least 90 percent of final values for pre-filters and after-filters.

a. Air handling unit and all other fans, cubic feet per minute: Minus 5 percent to plus l0 percent.
b. Air terminal units (maximum values): Minus 5 percent to plus l0 percent.
c. Exhaust hoods/cabinets: Minus 5 percent to plus l0 percent.
d. Minimum outside air: 0 percent to plus 10 percent.
e. Individual rooms**:** air outlets and inlets, and air flow rates not mentioned above: Minus 10 percent to plus l0 percent.
f. Individual rooms where both supply and return/exhaust air volume is indicated: Unless the A/E confirms that room pressurization is not a requirement, the difference between the total supply to a room and the total exhaust/return from that same room shall be 0 percent to plus l0 percent. The required difference is determined by subtracting one total (sum of values indicated at terminals in the room) from the other.

g. Heating hot water pumps: Minus 5 percent to plus five percent.
h. Chilled water and condenser water pumps and coils: Minus 5 percent to plus 10 percent.

3. Systems shall be adjusted for energy efficient operation as described in PART 3.
4. Typical TAB procedures and results shall be demonstrated to the A/E for one air distribution system (including all fans, three terminal units, three rooms) and one hydronic system (pumps and three coils) as follows:

a. When field TAB work begins.
b. During each partial final inspection and the final inspection for the project if requested by Owner.

E. 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.

F. TAB Report Forms: Use standard forms from AABC’s "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" or NEBB’s "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems."

G. Instrumentation Type, Quantity, and Accuracy: As described in AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems or NEBB's " Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems, " Section II, " Required Instrumentation for NEBB Certification."

## 1.6 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.

## 1.7 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:

B. Special Guarantee: Provide a guarantee on NEBB forms stating that NEBB will assist in completing requirements of the Contract Documents if TAB firm fails to comply with the Contract Documents. Guarantee shall include 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.

1.8 APPLICABLE PUBLICATIONS

A. The following publications form a part of this specification to the extent indicated by the reference thereto. In text, the publications are referenced to by the initials of the organization.

B. American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE): 2019 HVAC Applications ASHRAE Handbook, Chapter 39, Testing, Adjusting, and Balancing and Chapter 49, Noise and Vibration.

C. Associated Air Balance Council (AABC): 2016 7th Edition AABC National Standards for Total System Balance

D. National Environmental Balancing Bureau (NEBB):

1. 2019 9th Edition Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems

E. Sheet Metal and Air Conditioning Contractors National Association (SMACNA): 2002 3rd Edition HVAC SYSTEMS-Testing, Adjusting and Balancing.

PART 2 - PRODUCTS

2.1 PLUGS

A. Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 INSULATION REPAIR MATERIAL

A. See Division 23, Section 23070, "Mechanical Insulation". Provide for repair of insulation removed or damaged for TAB work.

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 01,017839, 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 air control valves, such as variable-air-volume boxes, to verify that they are accessible, and their controls are connected and functioning.

L. Examine system pumps to ensure absence of entrained air in the suction piping. Verify that start-up strainers have been removed from the pump suction diffusers.

M. Examine equipment for installation and for properly operating safety interlocks and controls.

N. 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. Spot-check thermostats to determine if they have been calibrated by the Control Contractor.
7. Sensors are located to sense only the intended conditions.
8. Sequence of operation for control modes is according to the Contract Documents.
9. Controller set points are set at indicated values.
10. Interlocked systems are operating.
11. Changeover from heating to cooling mode occurs according to indicated values.

O. 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. General: During TAB, all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

B. Coordinate TAB procedures with any phased construction completion requirements for the project. Provide TAB reports for each phase of the project prior to partial final inspections of each phase of the project.

C. Allow sufficient time in construction schedule for TAB and submission of all reports for an organized and timely correction of deficiencies.

D. 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" or NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" and this Section.

E. 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.

F. 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.

G. 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 CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure fan static pressures to determine actual static pressure as follows:

   a. Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.
   b. Measure static pressure directly at the fan outlet or through the flexible connection.
   c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.
   d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

2. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.
3. Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.
4. Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.
5. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

1. Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
2. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

C. Measure terminal outlets and inlets without making adjustments. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

D. Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
2. Adjust patterns of adjustable outlets for proper distribution without drafts.

## 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 schematic diagrams of systems' "as-built" piping layouts.

C. 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 ten percent of design.

B. If pump flow does not equal terminal flows, close a percentage of valves to simulate diversity.

C. Set calibrated balancing valves, if installed, at calculated pre-settings.

D. Measure flow at all stations and adjust, where necessary, to obtain first balance. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

E. Measure flow at main balancing station and set main balancing device to achieve flow that is five percent greater than indicated flow.

F. 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.

G. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

H. Measure the differential-pressure control valve settings existing at the conclusion of balancing.

## 3.8 PROCEDURES FOR PRIMARY-SECONDARY-FLOW HYDRONIC SYSTEMS

A. Balance the primary system crossover flow first, and then balance the secondary system.

## 3.9 PROCEDURES FOR STEAM SYSTEMS

A. Measure and record upstream and downstream pressure of each piece of equipment.

B. Measure and record upstream and downstream steam pressure of pressure-reducing valves.

C. Check the setting and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record the final setting.

D. Check the settings and operation of each safety valve. Record settings.

E. Verify the operation of each steam trap.

## 3.10 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.

## 3.11 PROCEDURES FOR CHILLERS

A. Balance water flow through each evaporator and condenser 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. If water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
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.

## 3.12 PROCEDURES FOR BOILERS

A. Measure entering-water temperature and flow and leaving steam pressure, temperature, and flow.

## 3.13 PROCEDURES FOR LABORATORY FUME HOODS

A. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located within the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.

B. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.

1. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
2. For laboratory fume hoods designed with integral makeup air, measure, adjust, and record the exhaust and makeup airflow.

C. For laboratory fume hoods that are connected to centralized exhaust systems using automatic dampers, adjust the damper controller to obtain the indicated exhaust airflow.

D. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
2. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening.

    a. For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
    b. Calculate and report the average face velocity by averaging all velocity measurements.
    c. Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
    d. If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.

3. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

## 3.14 PROCEDURES FOR EXHAUST HOODS

A. Measure, adjust, and record the airflow of each exhaust hood. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.

B. After balancing is complete, do the following:

1. Measure and record the static pressure at the hood exhaust-duct connection.
2. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

## 3.15 PROCEDURES FOR SPACE PRESSURIZATION MEASUREMENTS AND ADJUSTMENTS

A. Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

B. Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

C. Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

1. For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.
2. For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.
3. Test room pressurization first, then zones, and finish with building pressurization.

D. To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

E. For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

1. Compare the values of the measurements taken to the measured values of the control system instruments and report findings.
2. For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

F. In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

G. Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

## 3.16 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. Note operation of electric actuators using spring return for proper fail-safe operations.

## 3.17 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.

## 3.18 FINAL REPORT

A. General: 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. 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. Settings for supply-air, static-pressure controller.
    g. 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 and steam 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.

G. Apparatus-Coil Test Reports:

1. Coil Data:

   a. System identification.
   b. Location.
   c. Face area in square feet (sq. m).
   d. 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 degree F (degree C).
   e. Return-air, wet- and dry-bulb temperatures in degree F (degree C).
   f. Entering-air, wet- and dry-bulb temperatures in degree F (degree C).
   g. Leaving-air, wet- and dry-bulb temperatures in degree F (degree 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 degree F (degree C).
   k. Leaving-water temperature in degree F (degree C).

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 square feet (sq. m).
j. Minimum face velocity in fpm (m/s).

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 degree F (degree C).
d. Duct static pressure in inches wg (Pa).
e. Duct size in inches (mm).
f. Duct area in square feet (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.

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 degree F (degree C).

L. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Room or riser served.
d. Coil make and size.
e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm (L/s).
b. Entering-water temperature in degree F (degree C).
c. Leaving-water temperature in degree F (degree C).
d. Water pressure drop in feet of head or psig (kPa).
e. Entering-air temperature in degree F (degree C).
f. Leaving-air temperature in degree F (degree C).

M. 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.

2. Water-Cooled Condenser Test Data (Indicated and Actual Values):

   a. Entering-water temperature in degree F (degree C).
   b. Leaving-water temperature in degree F (degree C).
   c. Entering-water pressure in feet of head or psig (kPa).
   d. Water pressure differential in feet of head or psig (kPa).

N. 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.

O. Boiler Test Reports:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Voltage at each connection.
g. Amperage for each phase.

2. Test Data (Indicated and Actual Values):

a. Operating pressure in psig (kPa).
b. Operating temperature in degree F (degree C).
c. Entering-water temperature in degree F (degree C).
d. Leaving-water temperature in degree F (degree C).
e. Safety valve settings in psig (kPa).
f. High limit setting in psig (kPa).
g. Operating-control setting.
h. High-fire set point.
i. Low-fire set point.
j. Voltage at each connection.
k. Amperage for each phase.
l. Draft fan voltage at each connection.
m. Draft fan amperage for each phase.

P. Air-to-Air Heat-Recovery Unit Reports:

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.

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. If fans are an integral part of the unit, include the following for each fan:

   a. Make and type.
   b. Arrangement and size.
   c. Sheave make, size in inches (mm), and bore.
   d. Sheave dimensions, center-to-center, and amount of adjustments in inches (mm).

4. Test Data (Indicated and Actual Values):

   a. Total exhaust airflow rate in cfm (L/s).
   b. Purge exhaust airflow rate in cfm (L/s).
   c. Outside airflow rate in cfm (L/s).
   d. Total exhaust fan static pressure in inches wg (Pa).
   e. Total outside-air fan static pressure in inches wg (Pa).
   f. Pressure drop on each side of recovery wheel in inches wg (Pa).
   g. Exhaust air temperature entering in degree F (degree C).
   h. Exhaust air temperature leaving in degree F (degree C).
   i. Outside-air temperature entering in degree F (degree C).
   j. Outside-air temperature leaving in degree F (degree C).
   k. Calculate sensible and total heat capacity of each airstream in MBh (kW).

## 3.19 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 20 percent of air outlets.
   b. Measure water flow of at least 20 percent of terminals.
   c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
   d. Measure space pressure of all locations.
   e. Verify that balancing devices are marked with final balance position.
   f. 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 Owner.
2. TAB firm test and balance engineer shall conduct the inspection in the presence of Owner.
3. Owner 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 eight-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.

## 3.20 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. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional testing, inspecting, and adjusting during near-peak summer and winter conditions.

## 3.21 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start of TAB.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230590

SECTION 230700 – HVAC INSULATION 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. Section Includes: Insulation materials and accessories.

B. New Work: Completely insulate all new work as specified and scheduled.

C. Existing Work:

1. Insulate all existing piping and ductwork where existing insulation is damaged, as if it is new piping or ductwork.
2. Insulate all existing piping and ductwork that is currently not insulated, as if it is new piping or ductwork.

D. Coordination:

1. Coordinate size and location of supports, hangers, and insulation shields specified in other sections.
2. Coordinate clearance requirements with piping installer for piping insulation application, duct installer for duct insulation application, and equipment installer for equipment insulation application. Before preparing piping and ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.
3. Coordinate installation and testing of heat tracing.

1.3 SUBMITTALS

A. Product Data: Submit for each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).

1. Shop Drawings:
2. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
3. Detail attachment and covering of heat tracing inside insulation.
4. Detail insulation application at pipe expansion joints for each type of insulation.
5. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
6. Detail removable insulation at piping specialties, equipment connections, and access panels.

7. Detail application of field-applied jackets.
8. Detail application at linkages of control devices.
9. Detail field application for each equipment type.
10. Refer to applicable specification paragraph numbers (of the items discussed above) for coordination.

## 1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per 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 and inspecting 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 COORDINATION

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23, Section 230500, “Common Work Results for HVAC."

B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment 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.

C. Coordinate installation and testing of heat tracing before installation of insulation.

# PART 2 - PRODUCTS

## 2.1 INSULATION MATERIALS

A. Comply with requirements in Part 3 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. Thermal Requirements for all Insulation: Insulation thickness, conductivity (k) value and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

## 2.2 PIPE INSULATION

A. Glass Fiber Preformed Pipe Insulation: Glass fiber meeting ASTM C547, rigid molded. "K" value 0.23 at 75°F. Maximum service temperature shall not exceed 850°F. Jacket shall be high density, white Kraft bonded to aluminum foil for vapor barrier, reinforced with fiberglass yarn, permanently treated, secured with self-sealing longitudinal laps and butt strips or AP jacket with outward clinch expanding staples coated with vapor barrier mastic.

1. For interior use only. Do not use on exterior piping.
2. Basis of Design: Johns Manville "Micro-Lok HP."
3. Manufacturers:

   a. Johns Manville "Micro-Lok HP."
   b. Knauf Insulation "Earthwool 1000 Pipe Insulation."
   c. Owens-Corning “Fiberglas SSLII-ASJ.”

4. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

   a. Preformed Pipe Insulation: ASJ.

B. Polyisocyanurate Preformed Pipe Insulation: Rigid molded polyisocyanurate pipe insulation shall meet the requirements of ASTM C591 Type IV. Materials shall have a minimum thermal conductivity of 0.19 Btu-in. per sq.ft. per °F per hour at a mean temperature of 75°F when tested in accordance with ASTM C177 or ASTM C518, latest revisions. Maximum service temperature shall not exceed 300°F. The pipe insulation shall include a vapor retarder jacket with self-sealing longitudinal laps.

1. Basis of Design: HiTherm HT-300.
2. Manufacturers:

   a. HiTherm HT-300.
   b. Other Polyisocyanurate manufacturers shall be allowed only if they meet fire and smoke rating requirements for the specified thicknesses.

3. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.

   a. Preformed Pipe Insulation: ASJ.

## 2.3 EQUIPMENT AND DUCTWORK INSULATION

A. Thermal Requirements for all Equipment Insulation: Insulation thickness and/or R-value shall be as required by the local energy code or as indicated, whichever is greater.

B. Glass or 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. Basis of Design: CertainTeed Corp.; SoftTouch Duct Wrap.
2. Manufacturers:

    a. CertainTeed Corp.; SoftTouch Duct Wrap.
    b. Johns Manville; Microlite XG.
    c. Knauf Insulation; Duct Wrap.
    d. Manson Insulation Inc.; Alley Wrap.
    e. Owens Corning; Softr Duct Wrap FRK.

C. Glass or 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. For equipment applications, provide insulation with factory applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

1. Basis of Design: CertainTeed Corp.; CertaPro Commercial Board.
2. Manufacturers:

    a. CertainTeed Corp.; CertaPro Commercial Board.
    b. Johns Manville; 1000 Series Spin-Glas.
    c. Knauf Insulation; Insulation Board.
    d. Owens Corning; Fiberglas 700 Series.

D. Cellular Glass Insulation: Inorganic, closed cell, all glass, non-combustible with 0.2% (by volume) moisture absorption. Average density of 8 lb./cu. ft., 100 psi compressive strength, 900°F service temperature, 0.35 BTU/in./hr/sf/°F conductivity, R-value = 3.44 per inch.

1. Basis of Design: Pittsburgh Corning "Foamglas One."
2. Manufacturers:

    a. Cell-U-Foam Corporation "Ultra-CUF".
    b. Pittsburgh Corning "Foamglas One."

3. Field-Applied Jacket: Requirements are specified in "Field-Applied Jackets" Article.

    a. Block Insulation: ASTM C 552, Type I.
    b. Special-Shaped Insulation: ASTM C 552, Type III.
    c. Board Insulation: ASTM C 552, Type IV.
    d. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

## 2.4 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 a NRTL acceptable to authority having jurisdiction.

1. Basis of Design: 3M; Fire Barrier Duct Wrap 615 Plus.
2. Manufacturers:

    a. CertainTeed Corp.; Fyre Wrap Max 2.0.

b. Johns Manville; Firetemp SL-2.0 Wrap.
c. 3M; Fire Barrier Duct Wrap 615 Plus.

## 2.5 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

B. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.

C. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.

D. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

E. PVDC Jacket for Indoor Applications: 4-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.

1. Manufacturers:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

F. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

1. Manufacturers:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

G. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

1. Manufacturers:

a. Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

## 2.6 FIELD APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.

B. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.

C. Jacketing of Ducts and Pipes Exposed to Weather: All ductwork and piping exposed to weather shall be finished with an aluminum jacket over the insulation. Aluminum jacket material shall be embossed or corrugated sheet, 0.016" nominal thickness, conforming to ASTM B209, temper H-14. Jacketing shall be applied with joints lapped not less than 2” and shall be secured with 3/8" x 0.020" thick aluminum bands located at each circumferential lap and at not more than 9" intervals throughout. Horizontal joints shall lap downward to shed water. Vertical joints shall be sealed with weatherproof silicone sealant.

1. Basis of Design: Childers Products, Division of ITW "Metal Jacketing Systems."
2. Manufacturers:

    a. Childers Products, Division of ITW.
    b. Pabco Metals Corporation.
    c. RPR Products Inc, "Insul-Mate".

3. Be careful to consider jacketing requirements for piping that may be outdoors, but not exposed to weather. Such piping may include piping in parking garages, within covered loading docks, etc. Make sure documents adequately address different requirements for different situations.

D. PVC Plastic: One-piece molded type fitting covers and jacketing material, gloss white. Connections, tacks, pressure sensitive color matching vinyl tape. PVC material shall be 25 flame spread and 50 smoke development rated per ASTM E-84.

1. Basis of Design: Johns Manville "Zeston 2000 PVC".
2. Manufacturers:

    a. Johns Manville "Zeston 2000 PVC".
    b. Proto Engineered Thermoplastics Corp. "Proto Fitting Cover System".
    c. P.I.C. Plastics, Inc.; FG Series.
    d. Speedline Corporation "Smoke-Safe".

E. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure sensitive, acrylic-bases adhesive covered by a removable protective strip.

1. Basis of Design: Dow Chemical Company Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder tape.
2. Manufacturers:

    a. Dow Chemical Company Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder tape.

F. Underground Cellular Glass Pipe Jacket: The underground direct buried jacket shall be 125-mil thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.

1. Basis of Design: Pittsburgh Corning "Pittwrap CW Plus" with "Pittcote 300."
2. Manufacturers:

    a. Pittsburgh Corning "Pittwrap CW Plus" with "Pittcote 300."
    b. Polyguard "Insulrap No Torch 125".

G. Canvas Jacket: UL listed fabric, 6 oz/sq.yd. plain weave cotton treated with dilute fire-retardant lagging adhesive. Manufacturer: Great Lakes Textiles Product Style 1979.

H. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. Alpha Associates, Inc.; Alpha-Maritex 84215 and 84217/9485RW, Luben 59.

I. Butt Straps: Materials shall be identical in all respects and appearance to the basic jacket material.

## 2.7 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

1. Basis of Design: P. K. Insulation Mfg. Co., Inc.; "Super-Stik".
2. Manufacturers:

a. Insulco, Division of MFS, Inc.; "Triple I"
b. P. K. Insulation Mfg. Co., Inc.; "Super-Stik".
c. Ramco Insulation, Inc.; "Supertemp 1900".

B. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement 100 to 1200 degree: Comply with ASTM C 449/C 449M.

1. Basis of Design: P. K. Insulation Mfg. Co., Inc" PK No. 127" and "Quik-Cote".
2. Manufacturers:

a. Insulco, Division of MFS, Inc.; "Smooth Kote".
b. P. K. Insulation Mfg. Co., Inc.; "Quik-Cote".
c. Ramco Insulation, Inc.; "Ramcote 1200".
d. Rock Wool Manufacturing Company; "Delta One Shot".

## 2.8 ADHESIVES AND MASTICS

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. Obtain insulation and/or jacket manufacturer approval for all adhesives and mastics used. Obtain A/E approval for all locations where mastics will be used.

1. Adhesives shall not be considered an acceptable alternative to specified mechanical fastening methods without prior A/E approval.
2. All adhesives and mastics shall be suitable for the moisture conditions and temperatures that will be encountered.

B. Cellular-Glass Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F (minus 59 to plus 149 deg C).

1. Basis of Design: Childers Products, Division of ITW; CP-96.
2. Manufacturers:

a. Childers Products, Division of ITW; CP-96.
b. Foster Products Corporation, H. B. Fuller Company; 81-33.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

1. Basis of Design: Armacell LCC; 520 Adhesive.
2. Manufacturers:

a. Aeroflex USA Inc.; Aeroseal.
b. Armacell LCC; 520 Adhesive.
c. Foster Products Corporation, H. B. Fuller Company; 85-75.
d. RBX Corporation; Rubatex Contact Adhesive.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

1. Basis of Design: Childers Products, Division of ITW; CP-82.
2. Manufacturers:

a. Childers Products, Division of ITW; CP-82.
b. Foster Products Corporation, H. B. Fuller Company; 85-20.
c. Marathon Industries, Inc.; 225.
d. Mon-Eco Industries, Inc.; 22-25.

E. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Basis of Design: Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
2. Manufacturers:

a. Dow Chemical Company (The); 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; Speedline Solvent Weld Adhesive.

F. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.

1. Basis of Design: Childers Products, Division of ITW; CP-35.
2. Manufacturers:

a. Childers Products, Division of ITW; CP-35.
b. Foster Products Corporation, H. B. Fuller Company; 30-90.
c. Marathon Industries, Inc.; 590.
d. Mon-Eco Industries, Inc.; 55-40.

3. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
4. Service Temperature Range: Minus 20 to plus 180 deg F.
5. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
6. Color: White.

G. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.

1. Basis of Design: Childers Products, Division of ITW; CP-10 and CP-11.
2. Manufacturers:

a. Childers Products, Division of ITW; CP-10, CP-11.
b. Foster Products Corporation, H. B. Fuller Company; 35-00.
c. Marathon Industries, Inc.; 550.
d. Mon-Eco Industries, Inc.; 55-50.

## 2.9 SEALANTS

A. Joint Sealants: Joint Sealants for Cellular-Glass, and Polyisocyanurate Products:

1. Basis of Design: Mon-Eco Industries, Inc. "44-05".
2. Manufacturers:

a. Childers Products, Division of ITW; "CP-76".
b. Foster Products Corporation"30-45N".
c. Mon-Eco Industries, Inc. "44-05".
d. Pittsburgh Corning Corporation Pittseal "444".

B. FSK and Metal Jacket Flashing Sealants: Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250-degree F service temperature range. Color shall be aluminum.

1. Basis of Design: Mon-Eco Industries, Inc. "44-05".
2. Manufacturers:

a. Childers Products, Division of ITW; "CP-76-8".
b. Foster Products Corporation"95-44".
c. Mon-Eco Industries, Inc. "44-05".

C. ASJ Flashing Sealants, and PVDC, and PVC Jacket Flashing Sealants. Materials shall be compatible with insulation materials, jackets, and substrates. Fire- and water-resistant, flexible, elastomeric sealant. Minus 40 to plus 250-degree F service temperature range. Color shall be white.

1. Manufacturer:

a. Childers Products, Division of ITW; "CP-76".
b. Foster Products Corporation"95-44".
c. Marathon Industries, Inc.; 405.
d. Mon-Eco Industries, Inc. "44-05".

## 2.10 TAPES

A. ASJ Tape: White, 3-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

1. Basis of Design: Compac Corp. "104 and 105".
2. Manufacturers:

    a. Avery Dennison Corporation, Specialty Tapes Division "FT 2150".
    b. Compac Corp. "104 and 105".
    c. Ideal Tape Co., Inc., an American Biltrite Company; "428 AWF ASJ".
    d. Venture Tape; "1540 CW Plus, 1542 CW Plus", and "1542 CW Plus/SQ".

B. FSK Tape: Foil-face, three-inch wide, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

1. Basis of Design: Compac Corp. "110 and 111".
2. Manufacturers:

    a. Avery Dennison Corporation, Specialty Tapes Division "Fasson 0827".
    b. Compac Corp. "110 and 111".
    c. Ideal Tape Co., Inc., an American Biltrite Company; "491 AWF FSK".
    d. Venture Tape; "1525 CW Plus, 1528 CW Plus", and "1542 CW Plus/SQ".

C. PVC Tape: White, 2-inch wide, vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.

1. Basis of Design: Compac Corp. "130".
2. Manufacturers:

    a. Avery Dennison Corporation, Specialty Tapes Division "Fasson 9200".
    b. Compac Corp. "130".
    c. Ideal Tape Co., Inc., an American Biltrite Company; "370 White PVC".
    d. Venture Tape; "1506 CW NS".

D. PVDC Tape for Indoor Applications: White, three-inch wide, vapor-retarder PVDC tape with acrylic adhesive. Manufacturer: Dow Chemical Company "Saran 540 Vapor Retarder Tape".

E. PVDC Tape for Outdoor Applications: White, three-inch wide, vapor-retarder PVDC tape with acrylic adhesive. Manufacturer: Dow Chemical Company "Saran 560 Vapor Retarder Tape".

## 2.11 SECUREMENTS

A. Bands:

1. Manufacturers:

    a. Childers Products.
    b. Gerrard & Co.
    c. PABCO Metals Corporation.
    d. RPR Products, Inc.

PART 3 - EXECUTION

3.1 MINIMUM INSULATION SCHEDULE

A. Fiberglass insulation shall not be used outdoors.

B. Duct insulation:

1. Supply within unconditioned spaces (above ceilings, within shafts and within mechanical rooms): R-6.

   a. 2” thick, 0.75 lb./cu.ft. mineral or glass fiber blanket.
   b. 1-1/2” thick, 2.25 lb./cu.ft. mineral or glass fiber board.

2. Supply and return outside the building envelope: R-12.

   a. 4” thick, 0.75 lb./cu.ft. mineral or glass fiber blanket.
   b. 3” thick, 2.25 lb./cu.ft. mineral or glass fiber board.

3. Return, relief, and exhaust within the building envelope, upstream of shut-off dampers: none required.
4. Outside air intake: within conditioned space upstream of automatic isolation damper.

   a. Greater than 2,800 cfm: R-value shall equal roof or wall values.

      1) 6” thick, 0.75 lb./cu.ft. mineral or glass fiber blanket.
      2) 5” thick, 2.25 lb./cu.ft. mineral or glass fiber board.

   b. Less than 2,800 cfm: R-7.

      1) 3” thick, 0.75 lb./cu.ft. mineral or glass fiber blanket.
      2) 2” thick, 2.25 lb./cu.ft. mineral or glass fiber board.

5. Outside air intake: within conditioned space, downstream of automatic isolation damper: R-7.

   a. 2.2” thick, 0.75 lb./cu.ft. mineral or glass fiber blanket.
   b. 2” thick, 2.25 lb./cu.ft. mineral or glass fiber board.

6. Supply, return, outside air intake, not within conditioned space in concrete or below grade: Minimum R-5.3.

   a. 2” 7.3 lb./cu.ft. cellular glass.

C. Heating water piping, chilled water piping, steam piping and steam condensate piping:

| Fluid Operating Temperature Range and Usage (°F) | Insulation Conductivity | | Nominal Pipe or Tube Size in Inches (a) | | | | |
|---|---|---|---|---|---|---|---|
| | Conductivity Btu·in./(h·ft²·°F) | Mean Rating Temperature, °F | < 1 | 1 to < 1 ½ | 1 ½ to ≤ 4 | 4 to < 8 | ≥ 8 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| > 350 | 0.32 – 0.34 | 250 | 4.5 | 5.0 | 5.0 | 5.0 | 5.0 |
| 251 – 350 | 0.29 – 0.32 | 200 | 3.0 | 4.0 | 4.5 | 4.5 | 4.5 |
| 201 – 250 | 0.27 – 0.30 | 150 | 2.5 | 2.5 | 2.5 | 3.0 | 3.0 |
| 141 – 200 | 0.25 – 0.29 | 125 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 |
| 105 – 140 | 0.21 – 0.28 | 100 | 1.0 | 1.0 | 1.5 | 1.5 | 1.5 |
| 40 – 60 | 0.21 – 0.27 | 75 | 0.5 | 0.5 | 1.0 | 1.0 | 1.0 |
| <40 | 0.20 – 0.26 | 75 | 0.5 | 1.0 | 1.0 | 1.0 | 1.5 |

1. For piping smaller than 1 ½ inch (38 mm) and located in partitions within conditioned spaces, reduction of these thickness by 1 inch shall be permitted but not to a thickness less than 1 inch.

D. Service Schedule:

| System | Operating Temp. (°F) | Material |
|---|---|---|
| Low Pressure Steam (0-15 psig) | 212-250 | Glass-Fiber<br>Cellular Glass<br>Polyiso. or Phenolic<br>Calcium Silicate |
| Medium Pressure Steam (16-125 psig) | 251-349 | Glass-Fiber<br>Cellular Glass<br>Calcium Silicate |
| High Pressure Steam (126-245 psig) | 350-399 | Glass-Fiber<br>Cellular Glass<br>Calcium Silicate |
| Steam Condensate, Hot Service Drains | <250 | Glass-Fiber<br>Cellular Glass<br>Polyiso. or Phenolic<br>Calcium Silicate |
| Hot Service Vents | 212-250 | Glass-Fiber<br>Cellular Glass<br>Polyiso. or Phenolic<br>Calcium Silicate |
| Heating Water | 120-180 | Glass-Fiber<br>Cellular Glass<br>Polyiso. or Phenolic |

| | | |
|---|---|---|
| | | Elastomeric |
| Chilled Water | 40-60 | Glass-Fiber<br>Cellular Glass<br>Polyiso. or Phenolic<br>Elastomeric |

Notes:

1. Polyisocyanurate allowed only if it meets fire and smoke rating requirements at this thickness.
2. Use Calcium Silicate only for inserts at pipe saddles and hangers

E. Outdoor Cooling Tower/Condenser Water Pipe Insulation: Cellular Glass, Polyisocyanurate or Phenolic; 2 inches with aluminum jacket (polyisocyanurate allowed only if it meets fire and smoke rating requirements at this thickness).

F. Equipment; provide the following on any equipment that is not factory insulated:

1. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Mineral-fiber board, phenolic or polyisocyanurate: 1 inch thick.

2. Chilled-water expansion/compression tank and air separator insulation shall be one of the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Mineral-Fiber pipe and tank: 1 inch thick.
   c. Phenolic or Polyisocyanurate: 1 inch thick.

3. Steam condensate tank and receiver insulation shall be one of the following:

   a. Phenolic or polyisocyanurate: 2 inches thick.
   b. Mineral-Fiber pipe and tank: 2-1/2 inches thick and 3-lb/cu. ft. nominal density.

4. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:

   a. Cellular Glass: 6 inches thick.
   b. Mineral-fiber pipe and tank, phenolic or polyisocyanurate: 4-1/2 inches thick.

5. Chilled-water pump insulation shall be one of the following:

   a. Cellular Glass: 1-1/2 inches thick.
   b. Mineral-Fiber board: 1 inch thick.
   c. Phenolic or Polyisocyanurate: 1 inch thick.

6. Steam condensate pump and boiler feedwater pump insulation shall be the following:

   a. Phenolic or polyisocyanurate: 2 inches thick.
   b. Mineral-Fiber Board: 2-1/2 inches thick and 3-lb/cu. ft. nominal density.

7. Insulation on chilled water pumps:

   a. Fabricate metal boxes lined with insulation. Insulation shall be as indicated above for specific service. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch-diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
   b. Fabricate boxes from galvanized steel, at least 0.050 inch thick.
   c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
   d. Box and insulation shall not be required on small fractional HP in-line pumps.
   e. A neoprene wrap is an acceptable alternative to a box.

G. Valves and pipe fittings shall be insulated as indicated below.

## 3.2 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application. Before insulating, apply a corrosion coating to insulated surfaces as follows:

   1. Stainless Steel: Coat 300 series stainless steel with an epoxy primer 5 mils thick and an epoxy finish 5 mils thick if operating in a temperature range between 140 and 300 deg F. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
   2. Carbon Steel: Coat carbon steel operating at a service temperature between 32 and 300 deg F with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.

B. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

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 INSULATION WORK IN GENERAL

A. General: Except as specified, material shall be installed in accordance with the recommendations of the manufacturer.

   1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.

2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
3. 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.
4. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
5. Install insulation with least number of joints practical.
6. Install insulation with longitudinal seams at top and bottom of horizontal runs.
7. Do not apply insulation until surfaces to be covered have been leak tested, have had rust and scale removed, and have been cleaned, dried, and inspected.
8. Insulation shall always be kept dry and clean.
9. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.

    a. Install insulation continuously through hangers and around anchor attachments.
    b. 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.
    c. 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.
    d. 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.
    e. Continue insulation vapor barrier through penetrations except where prohibited by code.

11. Continue pipe insulation through gypsum and masonry walls only if fire stopping specified in Division 07 has a UL Listed assembly that includes a jacketed insulation. Coordinate with General Contractor.
12. Install insulation with factory-applied jackets as follows:

    a. Draw jacket tight and smooth.
    b. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
    c. Overlap jacket longitudinal seams at least 1-1/2 inches. 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 o.c.
    d. For below ambient services, apply vapor-barrier mastic over staples.
    e. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
    f. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.

13. All work shall be performed at ambient and equivalent temperatures as recommended by the manufacturers.

14. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
15. Joints shall be staggered on multi-layer insulation.
16. Do not apply insulation until heat tracing specified elsewhere in other sections of this Specification is completed and tested.
17. Mineral fiber thermal insulating cement shall be mixed with demineralized water when used on stainless steel surfaces.
18. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

## 3.4 INSULATION INSTALLATION, PIPING

A. General: Pipe insulation shall be installed in strict conformance to the manufacturer's recommendations. Pipe insulation shall be continuous and installed on all fittings and appurtenances unless specified otherwise. Installation shall be with full-length units of insulation and using a single-cut piece to complete a run. Provide jackets for all pipe insulation.

B. Insulation Installation on Straight Pipes and Tubes:

1. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
2. Secure laps with outward clinched staples at six inches o.c, for insulation with factory-applied jackets on above ambient surfaces.
3. Do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant, for insulation with factory-applied jackets on below-ambient surfaces.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with **wire or** bands.

D. Polyisocyanurate Insulation:

1. All insulation shall be tightly butted and free of voids and gaps. Vapor retarder, if used, must be continuous. All fasteners and bands shall be neatly aligned.
2. In below-ambient systems, staple, rivets, screws, and other fasteners capable of penetrating the vapor retarder shall not be used.
3. Install prefabricated insulation fittings on elbows, tees, and valves. Insulation at fittings shall be the same type and thickness as on straight pipe sections.
4. Lap joints of vapor retarder jacket shall be sealed using SSL tape or manufacturer's vapor retarder tape.
5. Elbows and fittings shall be wrapped with vapor retarder tape in a spiral fashion, using a 50% overlap between successive courses of tape.

E. Unions, Flanges, Couplings, Strainers, and Valves:

1. Insulate all fittings, flanges, couplings, strainers, valves (and similar accessories) associated with an insulated piping system unless indicated otherwise.
2. Exposed Work: On exposed work, insulate to a diameter equal to insulation of adjacent piping provided a minimum of 0.75” of insulation is maintained around fittings, couplings, strainers and valves, otherwise, increase diameter.
3. Concealed Work: On concealed work, increase insulation diameter to maintain same insulation thickness as on adjacent piping. Use same material as specified for adjacent piping; fitting covers to be as specified hereinafter.
4. Adjustable and Serviceable Valves and Accessories: Where balancing valves, strainers and similar devices are adjustable or require servicing on less than a five-year cycle, provide removable insulation sections. Where valves with repackable glands and similar devices allow service, but manufacturer does not anticipate service frequency to be less than five years, make reasonable provisions to allow removal and reinstallation of the same materials with minimal effort and potential for damage.

F. Thermometer and Test Wells: Insulate test thermometer, industrial thermometer, and other test wells over their exterior length. Insulate thermometer wells protruding above finish pipe or equipment insulation. Neatly taper insulation away from top of well. Insulation on thermometer wells shall be 1-1/2" minimum thickness.

G. Insulation Support at Hangers:

1. Provide support shield and 360 degree insert between support shield and piping on piping 1-1/2" diameter and larger. Fabricate insert from heavy density insulating material suitable for the temperature. Shield shall be fabricated of 14-gauge galvanized sheet metal. Insulation shields and inserts shall be not less than the following lengths:

| | |
|---|---|
| 1/2" to 2-1/2" | 10" |
| 3" to 6" | 12" |
| 8" to 10" | 16 |

2. Vapor-barrier facing of the insert shall be of the same material as the facing on the adjacent insulation. Seal inserts into the insulation with lagging adhesive for vapor seal. Where anchors are secured to insulated chilled piping, insulate anchors same as piping for a distance not less than four times insulation thickness to prevent condensation.

H. Sleeves and Wall Chases: Insulation on pipes through walls and floors shall be full size and jacketed same as adjacent insulation. Provide a metal jacket over the insulation on pipe passing through sleeves in non-fire rated walls where caulking is required.

1. Where penetrating interior walls, extend the metal jacket two inches out on either side of the wall and secure on each end with a band.
2. Provide adequate support on vertical pipe to prevent slipping.

I. Allowances for Movement: At points where pipe will move during expansion and contraction (expansion joints, Z-bends, expansion loops, etc.), clearances between the pipe and encased insulation shall be sized to permit full pipe movement without cracking or damaging insulation and casing or jacket.

J. Insulation at Mechanical Pipe Couplings: PVC insulated fitting covers shall be applied after the installation is installed. Installation shall comply with the manufacturer's recommended procedures. Connection with the pipe insulation shall be done in a neat, finished appearance, and any required vapor barrier shall be maintained.

K. Insulation Within Reach of Building Occupants: Where insulation is within reach of building occupants and visitors, insulation surfaces shall be protected by smooth sheet aluminum jacket material, 0.016" nominal thickness, lapped, banded, and installed same as above. The term “within reach” is defined as within ten feet of the floor, except for cases where there is reasonable protection (in the opinion of the A/E) offered by objects located between the insulation and the floor. This does not apply to insulation concealed within wall or ceiling construction and insulation located within equipment rooms that can be locked off from the normal building occupants.

## 3.5 SPECIAL PIPE INSULATION REQUIREMENTS:

A. Sterilizers, Kitchen and Laundry Equipment Piping: Provide aluminum jackets over insulation on piping that connects to equipment (where exposed to view). Insulate steam filters and provide jackets, same as for piping. Provide escutcheons at wall, ceiling, or floor penetrations.

B. Cold Piping Insulation: Exposed ends of insulation shall be sealed with vapor retarding mastic installed per the manufacturer’s recommendations. Vapor seals at butt joints shall be applied at every fourth pipe section and at each fitting to isolate any water incursion.

C. Removable Insulation Sections: Installation shall conform to the following:

1. Fabricate removable insulation sections from sections of pipe insulation or block insulation as follows. Removable flexible blankets will be allowed with prior approval if adequate covering is provided. Vapor barrier must be maintained for cold surfaces.
2. When covers are made from sectional pipe insulation, extend insulation at least two times the insulation thickness over adjacent pipe insulation on each side of the component. Secure cover in place with stainless-steel hooks and wire.
3. When covers are made from block insulation, make two halves, each consisting of mitered blocks. Extend insulation at least two inches over adjacent pipe insulation on each side of the component. Fill space between the component and pipe insulation with insulating cement.

## 3.6 DUCTWORK AND PLENUM INSULATION INSTALLATION

A. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.

B. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.

C. 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:

1. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space three inches maximum from insulation end joints, and 16 inches o.c.
2. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and three inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
3. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
4. Do not over-compress insulation during installation.
5. Impale insulation over pins and attach speed washers.
6. 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.

D. 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 two inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, one-inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
2. Install vapor stops for ductwork and plenums operating below 50-degree F at 18-foot 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 three inches.

E. Overlap unfaced blankets a minimum of two inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.

F. 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.

G. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with six-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced six inches o.c.

## 3.7 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

A. Glass Fiber Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
3. Protect exposed corners with secured corner angles.

4. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
5. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
6. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.

## 3.8 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. Terminate insulation above roof surface and seal with joint sealant for applications requiring only indoor insulation. Install insulation for outdoor applications tightly joined to indoor insulation ends for applications requiring indoor and outdoor insulation. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches 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. Terminate insulation inside wall surface and seal with joint sealant for applications requiring only indoor insulation. Install insulation for outdoor applications tightly joined to indoor insulation ends for applications requiring indoor and outdoor insulation. Seal joint with joint sealant.
3. 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 Floor, Wall, and Partition Penetrations: Install insulation continuously through penetrations of fire-rated floors, walls, and partitions if firestop is rated for this approach. Obtain further direction from A/E if firestopping is not rated for insulated penetrations. Comply with requirements in **Division 07 Section** 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."

## 3.9 FIELD-APPLIED JACKET INSTALLATION

A. General: Where field-applied jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with two-inch overlap at seams and joints.
2. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where metal jackets are indicated, install with two-inch 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 o.c. and at end joints.

## 3.10 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230700

SECTION 230800 – COMMISSIONING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes requirements for commissioning the HVAC system, its subsystems and equipment, and parts of the Plumbing and Electrical Systems. This includes the new construction and existing systems that will serve the new construction or are being renovated. This Section supplements the general requirements specified in Division 01 Section "General Commissioning Requirements."

B. See Division 01 Section "General Commissioning Requirements" for general requirements for commissioning processes that apply to this Section.

C. The owner is committed to commissioning this facility to systematically optimize the building and ancillary systems so that they operate efficiently and effectively in accordance with the Owners Project Requirements, and that the facility staff have adequate system documentation, and training. It is the intent of the owner to ensure that the fundamental systems are calibrated and operate as required to deliver functional and efficient performance.

D. The CxA will plan, manage, perform, and report on the commissioning activities, utilizing the reporting formats and standardized forms provided by the CxA. The CxA will submit deliverable report to USDA APHIS according to a project schedule set by CxA and agreed upon by USDA APHIS. It is extremely important that all commissioning tasks be conducted in a transparent manner and involve the operations staff to the greatest degree possible.

1.2 REFERENCES

A. The publications listed below form a part of this specification to the extent referenced.

1. ASHRAE

a. ASHRAE Guideline 0-2019: The Commissioning Process
b. ASHRAE Guideline 1.1-2007: HVAC&R Technical Requirements for the Commissioning Process

2. ANSI

a. ANSI/ASHRAE/IES Standard 202-2018: The Commissioning Process Requirements for Buildings and Systems

1.3 DEFINITIONS

A. Acceptable Performance: A component or system being able to meet specified design parameters under actual load including satisfactory documented completion of functional performance tests, control system trending and resolution of outstanding issues.

B. Acceptance Phase: The phase of construction after startup and initial checkout when functional performance tests, O&M documentation review and operations & maintenance staff training occurs.

C. Basis of Design (BOD): A document prepared by the Designer of Record that records concepts, calculations, decisions, and product selections used to meet the Owner's Project Requirements (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.

D. Building Envelope: Products, assemblies, equipment and systems that comprise the building exterior; including but not limited to foundations, floors, walls, doors, windows, openings, skylights, roof, and air barriers.

E. Commissioning (Cx): Documented confirmation that building systems function in compliance with criteria set forth in the Contract Documents and OPR.

F. Commissioning Authority (CxA): An independent entity designated by the Owner, not associated with the General Contractor. This entity oversees and recommends approval of the completion of all General Contractor commissioning activities.

G. Commissioning Coordinator (CC): A representative responsible for coordinating commissioning activities on behalf of the subcontractor. Each CC will participate as a member of the project Commissioning Team.

H. Commissioning Plan: A document prepared by the CxA that outlines the Cx team organization, communication paths, schedule, allocation of resources, matrix of responsibilities, installation/testing requirements, and documentation requirements of the commissioning process.

I. Commissioning Report: A document prepared by the CxA at completion of the project.

J. Commissioning Specialist (CxS): Individual designated by the Contractor as the construction team primary point of contact for coordination of commissioning activities with the subcontractors, Owner and CxA.

K. Commissioning Team: Owner and Contractor entities/individuals that participate in the commissioning process.

L. Contractor: The construction team including the prime contractor, subcontractors, vendors, suppliers and other construction entities associated with the General Contractor’s contract.

M. Functional Performance Test (FPT): A test used to verify and document the full range of components, systems, and assemblies function in accordance with the Contract Documents.

N. Issue: A condition in the installation or function of a component, piece of equipment, or system that does not appear to be in compliance with the contract documents or Owner Project Requirements (OPR).

O. Issues Log: A list of systems/equipment installation or performance issues that have been noted. The list is prepared by the CxA. It includes the current disposition of each issue and the date and description of final resolution.

P. Owner: Entity with the highest level of responsibility for directing the project.

Q. Owner Project Requirements (OPR): Non-technical document developed by the Owner. It is updated at regular intervals to state the intended concepts, goals, budget, performance, and other criteria to which the completed project must conform. It includes expectations of how the building will be used and operated. This document is the basis for building commissioning. It is used to develop the basis of design documentation.

R. Pre-functional Checklist (PFC): Criteria used to verify that equipment/system/assembly installations, start-up, and operation comply with the Contract Documents, equipment submittals, and manufacturers' instructions.

S. Seasonal Performance Tests: Functional tests that are scheduled at such time when system design conditions can be replicated or simulated.

T. Start-up: The initial start-up or activation of dynamic equipment.

U. Subcontractor: Member of the Contractor construction team providing a service or product.

V. Systems Manual: A manual that provides information needed to understand, operate, and maintain the equipment/systems/assemblies.

W. Trending: Monitoring of equipment and sequences using the building control system or data loggers.

## 1.4 CONTRACTOR'S RESPONSIBILITIES

A. Each Contractor:

1. Attend procedures meeting for TAB Work.
2. Perform commissioning tests at the direction of the CxA.
3. Attend controls coordination meeting.
4. Participate in systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.
5. Perform commissioning tests at the direction of the CxA.
6. Provide information requested by the CxA for final commissioning documentation.
7. Certify that TAB Work is complete.

B. Mechanical Contractor:

1. Attend TAB verification testing.
2. Provide measuring instruments and logging devices to record test data, and data acquisition equipment to record data for the complete range of testing for the required test period. The CxA shall provide any calibrated instruments, necessary for commissioning, which are not provided by the contractors.

3. HVAC Instrumentation and Control Contractor: With the CxA, review control designs for controllability with respect to actual equipment to be installed, and recommend adjustments to control designs and sequence of operation descriptions.

C. TAB Contractor:

1. Contract Documents Review: With the CxA, review the Contract Documents before developing TAB procedures.
2. Verify the following:

   a. Accessibility of equipment and components required for TAB Work.
   b. Adequate number and placement of duct balancing dampers to allow proper balancing while minimizing sound levels in occupied spaces.
   c. Adequate number and placement of balancing valves to allow proper balancing and recording of water flow.
   d. Adequate number and placement of test ports and test instrumentation to allow reading and compilation of system and equipment performance data needed to conduct both TAB and commissioning testing.

3. This review of the Contract Documents by the TAB Subcontractor satisfies requirements for a design review report as specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."
4. Additional Responsibilities: Participate in tests specified in Division 23 Sections "Instrumentation and Control for HVAC".

D. Electrical Contractor:

1. With the Mechanical Contractor, coordinate installations and connections between and among electrical and HVAC systems.
2. Attend TAB verification testing of electrical equipment.

## 1.5 QUALITY CONTROL

A. General Contractor Commissioning Specialist (CxS): The General Contractor shall designate a CxS to lead and coordinate all commissioning activities for the Contractor.

1. CxS shall possess the qualifications of an individual experienced with the commissioning of building systems of similar scope and complexity to those included under this contract. Experience as a construction project manager or superintendent is desirable.
2. Upon request, qualifications of the proposed CxS shall be submitted to the Owner for review and approval. The Owner will notify the Contractor if a change of CxS is required. If a change of CxS becomes necessary. The Contractor shall submit qualifications of the replacement CxS for review and approval.
3. CxS presence at all scheduled commissioning meetings is required.
4. CxS shall coordinate and supervise all commissioning related activities with the Subcontractors, Vendors, CxA and Owner.

B. Subcontractor Commissioning Coordinators (CC) – Individual assigned as the lead on each subcontractor team and responsible to coordinate commissioning activities with the CxS.

1. Contractor is required to identify a CC on each subcontractor team and delegate all commissioning responsibilities through subcontracts.
2. CC presence at all scheduled commissioning meetings is required.
3. CC provides regular input on commissioning activities and issues resolution.
4. Alternates shall be identified during CC absences.

C. Commissioning Meetings:

1. CxA will organize and lead regular commissioning meetings.
2. Meeting agendas typically include general status discussion, commissioning schedule updates, status of the electronic data management documentation progress, installation & testing progress, Issues Log review, and issues resolution.
3. CxA will provide meeting minutes to the Owner for distribution to the Contractor.
4. Contractor shall require CxS and CC attendance at the meetings to coordinate commissioning activities and resolve issues.

## 1.6 COMMISSIONING DOCUMENTATION

A. Test Checklists: CxA, shall develop test checklists for HVAC systems, subsystems, and equipment, including interfaces and interlocks with other systems. CxA shall prepare separate checklists for each mode of operation and provide space to indicate whether the mode under test responded as required.

1. Calibration of sensors and sensor function.
2. Testing conditions under which test was conducted, including (as applicable) ambient conditions, set points, override conditions, and status and operating conditions that impact the results of test.
3. Control sequences for HVAC systems.
4. Strength of control signal for each set point at specified conditions.
5. Responses to control signals at specified conditions.
6. Sequence of response(s) to control signals at specified conditions.
7. Electrical demand or power input at specified conditions.
8. Power quality and related measurements.
9. Expected performance of systems, subsystems, and equipment at each step of test.
10. Narrative description of observed performance of systems, subsystems, and equipment. Notation to indicate whether the observed performance at each step meets the expected results.
11. Interaction of auxiliary equipment.
12. Issues log.

## 1.7 SUBMITTALS

A. Testing Procedures: CxA shall submit detailed testing plan, procedures, and checklists for each series of tests. Submittals shall include samples of data reporting sheets that will be part of the reports.

B. Certificate of Readiness: CxA shall compile certificates of readiness from each Contractor certifying that systems, subsystems, equipment, and associated controls are ready for testing.

C. Certificate of Completion of Installation, Prestart, and Startup: CxA shall certify that installation, prestart, and startup activities have been completed. Certification shall include completed checklists provided by TAB Contractor as specified in Division 23 Section "Testing, Adjusting, and Balancing for HVAC."

D. Test and Inspection Reports: CxA shall compile and submit test and inspection reports and certificates, and shall include them in systems manual and commissioning report.

E. Corrective Action Documents: CxA shall submit corrective action documents.

F. Certified TAB Reports: CxA shall submit verified, certified TAB reports.

1.8 THE SYSTEMS TO BE COMMISSIONED ARE:

A. Chilled water system serving the AHU's and the growth chambers, including the control valves, coils, and pumps.

B. Variable speed drives on AHU fans and exhaust fans.

C. Condensate pumps

D. Piping, cleaning and flushing

E. Chemical treatment

F. Ductwork, including balancing dampers and shutoff dampers in supply, return, specialty exhaust, and general exhaust

G. Air handling units and all internal components, including the energy recovery core on the ERV.

H. General exhaust fans

I. Air Control Valves and duct heaters

J. Steam boiler system and feed water

K. Testing, Adjusting and Balancing work

L. Building automation system (controlled devices, control loops and system integration)

M. Electrical system – Feeders and spot check circuits for this project

N. Lighting controls

## PART 2 - PRODUCTS

### 2.1 TESTING EQUIPMENT

A. The Contractor shall provide all equipment and tools to facilitate testing and access to commissioned equipment including lighting, safety equipment, lifts and ladders, two-way radios, etc. Equipment shall be maintained in good repair and operational condition throughout the duration of use on the project.

### 2.2 TESTING EQUIPMENT PROVIDED

A. The Contractor shall provide all test equipment necessary to perform startup, initial checkout, and required functional performance tests. Special equipment, tools, and instruments available only from the vendor, specific to a piece of equipment, and required for testing shall be included in the base bid price and shall become the property of the Owner after testing has been completed, except for stand-alone data logging equipment. Data logging equipment and software required to test equipment shall not become the property of the Owner.

### 2.3 EQUIPMENT CALIBRATION

A. The Contractor is responsible for testing equipment calibration. Prior to testing, the Contractor shall provide documentation that the equipment has current calibration which can be traced to National Institute of Standards and Technology (NIST) calibration. All testing equipment shall be of sufficient quality and accuracy to test and measure system performance within the tolerances specified. Unless otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.9 degrees F and resolution of plus or minus 0.2 degrees F.
2. Pressure sensors shall have an accuracy of plus or minus 2.0 percent of the value range being measured (not the full range of the meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and recalibrated when dropped or damaged. Calibration tags shall be affixed or certificates readily available during testing.
4. Submit calibration documentation of all testing equipment with each testing episode. Serial numbers of equipment and standards used for Quality Control, zeroing, and calibration shall be included.

## PART 3 - EXECUTION

### 3.1 GENERAL

A. Commissioning is required as one quality measure of the construction of this building in order to assure that the final building meets the original intent of the owner’s design. Following is a summary of the commissioning process and scope of work the owner requests for this project.

1. Testing Preparation

    a. Certify that plumbing, electrical and HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.
    b. Certify 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 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. Set 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.

2. Testing and Balancing Verification

    a. Prior to performance of testing and balancing Work, provide copies of reports, sample forms, checklists, and certificates to the CxA.
    b. Notify the CxA at least 20 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 Contractor 10 days in advance of the date of field verification. Notice will not include data points to be verified.
        2) The testing and balancing Contractor 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. 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. Electrical feeder testing shall include performing an insulation resistance test using a test voltage of 1000 VDC for 1 minute with a megohmmeter.
e. The CxA along with the plumbing contractor, electrical contractor, HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for systems, subsystems, and equipment.
f. Tests will be performed using design conditions whenever possible.
g. 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.
h. The CxA may direct that set points be altered when simulating conditions is not practical.
i. 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.
j. If tests cannot be completed because of a deficiency outside the scope of the system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.
k. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

## 3.2 COMMISSIONING PROCESS DURING THE CONSTRUCTION PHASE

A. The commissioning process activities accomplished by the commissioning authority during the construction phase include:

1. Organize the commissioning process components and conduct a pre-construction meeting where the commissioning process requirements are reviewed with the commissioning team.
2. Coordinate and direct commissioning activities in a logical, sequential and efficient manner using consistent protocols, clear and regular communications and consultations with all necessary parties, frequently updated timelines, schedules, and technical expertise.
3. Perform site visits, as necessary, but no fewer than one per month, to observe component and system installations. Accomplish a statistical review of construction focusing on the owner's design intent and the quality process. Perform a static inspection of the installation to ensure that it is conforming to the drawings and specification. Submit checklists for these regular inspections as part of the commissioning plan.
4. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction-meeting minutes for revisions/substitutions relating to the owner's design intent. Assist in resolving any discrepancies.
5. With necessary assistance and review from the installing contractors, develop and write construction checklists. Submit to GC and owner for approval.
6. Organize and conduct periodic commissioning team meetings necessary to plan, develop the scope, coordinate, schedule activities and resolve problems.
7. Review submittals concurrent with the design professional’s review.

8. Work with contractors in completing construction checklists and tracking of checklist completion.
9. Statistically sample completion of construction checklists on a periodic basis to verify that contractor's quality process is achieving the owner's project requirements.
10. Approve systems startup by reviewing start-up reports and by selected site observation.
11. With necessary assistance and review from installing contractors, write the test procedures. Submit to A/E and owner for review and approval.
12. Assist GC in direction of the contractor to execute the tests.
13. Coordinate witness and recommend approval of test procedure performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.
14. Recommend approval of air and water systems balancing through statistical sampling of the report and separate field verification.
15. Maintain a master issues log and a separate testing record. Provide to the GC and owner written progress reports and test results with recommended actions.
16. Document the correction and retesting of non-compliance items by the contractor.
17. Reviews the systems manual for achieving the owner's project requirements.
18. Review, recommend pre-approval, and verify the training provided by the contractors.

## 3.3 COMMISSIONING PROCESS DURING THE OCCUPANCY AND OPERATIONS PHASE

A. The commissioning process activities accomplished by the commissioning authority during the occupancy and operations phase include:

1. Schedule and verify deferred and seasonal testing by the contractor.
2. Verify continuing training.
3. Complete the final Commissioning Process Report.
4. Return to the site at 3 months and at 10 months into the 12-month warranty period. Review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have with 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. Assist facility staff in developing reports and documents and requests for services to remedy outstanding problems.

## 3.4 COMMISSIONING AUTHORITY RESPONSIBILITIES

A. In addition to duties described above, the commissioning authority (CxA) will have the following responsibilities and authority:

1. Issue deficiency notices and verify that they have been corrected. An Issues Log will be maintained and reviewed at the commissioning meetings. Deficiencies that are not corrected in a timely manner will be reported to the owner.
2. The commissioning authority (CxA) is not required to:

a. Establish design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management. The CxA may assist with problem-solving or resolving non-conformance or deficiencies, but ultimately that responsibility resides with the general contractor and the design team. The CxA will report to the owner any deficiencies or discrepancies.
b. Issue change orders; they do review change orders for compliance with the construction documents. Non-compliances will be reported to the owner.

## 3.5 OBSERVATION AND TESTING REQUIREMENTS

| Equipment or Systems | Sampling Rate |
|---|---|
| *HVAC Systems* | |
| Air Handling Units | 100% |
| All exhaust fans | 100% |
| VFDs | 100% |
| Air Control Valves | 100% |
| Ductwork – supply, return, and exhaust | 40% |
| Isolation room ductwork | 100% |
| Piping – all systems | 40% |
| Temperature Control | 100% |
| Pumps | 100% |
| Glycol feeders | 100% |
| Steam traps | 100% |
| Cleaning/flushing | 100% |
| Water treatment | 100% |
| Pressure independent and standard control valves | 100% |
| *Building Automation Systems* | |
| Temperature/Humidity Sensors | 100% |
| Pressure Sensors and Controllers | 100% |
| Sequence of Operation | 100% |
| Airflow Stations | 100% |
| Damper/Valve Actuators | 100% |
| *Electrical Systems* | |
| Emergency Power Sequence | 100% |
| Lighting Controls | 100% |
| Feeders rated 200 Amps and above | 100% |

END OF SECTION 230800

SECTION 230900 – INSTRUMENTATION AND CONTROL 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.

B. Division 23, Section 230500, "Common Work Results for HVAC" is directly related to work included in this section. Other sections are indirectly related and shall be reviewed.

1.2 SUMMARY

A. A complete Energy Management and Control System (EMCS) shall be provided to control and/or to monitor building systems as outlined in the descriptions of operation, drawings, and this specification. The EMCS shall employ direct digital control (DDC).

1. Provide all software, hardware and cabling necessary for communication between operator stations, controllers, sensors, actuators, and other devices.
2. Provide all miscellaneous software, wiring, parts, and labor required in establishing a complete and working system that is an interoperable network capable of communicating with the existing EMCS.
3. Controls contractor shall be responsible for connecting all BACnet compatible equipment to the EMCS network. The connection may be via the contractor's specific network or ethernet. The controls contractor is not required to add BACnet translation devices for equipment that does not include a BACnet option by its manufacturer.

1.3 APPROVED MANUFACTURERS

A. Provide an HVAC control system with distributed processing units, input/output units, firmware, and standard operating software.

1. Design, component selection, installation, custom programming, documentation, testing, training, and warranty service shall be the direct responsibility of the manufacturer or their local representative.
2. New equipment and software shall be selected for compatibility with systems that are presently installed at the site.

1.4 DEFINITIONS

A. DDC: Direct digital control.

B. I/O: Input/output.

C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.

D. MS/TP: Master slave/token passing.

E. PC: Personal computer.

F. PID: Proportional plus integral plus derivative.

G. RTD: Resistance temperature detector.

## 1.5 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 eight 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 one-degree F.
    b. Water Flow: Plus or minus five percent of full scale.
    c. Water Pressure: Plus or minus two percent of full scale.
    d. Space Temperature: Plus or minus one-degree F.
    e. Ducted Air Temperature: Plus or minus one-degree F.
    f. Outside Air Temperature: Plus or minus two-degrees F.
    g. Dew Point Temperature: Plus or minus three-degrees F.
    h. Temperature Differential: Plus or minus 0.25-degrees F.
    i. Relative Humidity: Plus or minus five percent.
    j. Airflow (Pressurized Spaces): Plus or minus three percent of full scale.
    k. Airflow (Measuring Stations): Plus or minus five percent of full scale.
    l. Airflow (Terminal): Plus or minus 10 percent of full scale.
    m. Air Pressure (Space): Plus or minus 0.01-inch wg.
    n. Air Pressure (Ducts): Plus or minus 0.1-inch wg.
    o. Carbon Monoxide: Plus or minus five percent of reading.
    p. Carbon Dioxide: Plus or minus 50 ppm.
    q. Electrical: Plus or minus five percent of reading.

## 1.6 SUBMITTALS

A. Provide a complete set of reproducible control drawings using computer aided design and drafting (CADD) technology. Include the following information:

1. Show general physical arrangement of component devices installed in the panels. Indicate applicable detailed drawing reference.
2. Provide a typical schematic drawing of each control circuit.
3. Identify equipment and devices by the reference designations shown on the drawings and by unique point identification used in system software. Provide material list with or on each drawing.
4. Supply block diagrams and schematics showing riser diagrams, the layout of equipment, communication cabling, and wire type.
5. Provide system diagrams showing the general mechanical system layout with all sensors/devices of each mechanical system.
6. Supply floor plan drawings showing the location of all controlled equipment and devices used for sensing and control.
7. Provide a schematic drawing of each control circuit, complete with individual wire identifications. Typical drawings are acceptable.
8. Provide LAN truck riser diagram showing cable routing and location of all repeaters.

B. Provide descriptions of operation detailing all control strategies, including initial setpoints and referencing all points by the point name used in the BAS programming. These descriptions of operation shall also be provided in the record drawings.

C. Provide a complete list of equipment to be furnished, which includes a manufacturer's catalog sheet for each item on the material list.

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 description of Operation including schematic diagram.
4. Provide a damper schedule with one line per damper. Provide for each damper: The project TAG, the size, the model of the damper, the type and model of the actuator, and whether the damper fails open, closed, or in place.
5. Provide a valve schedule with one line per valve. Provide for each valve: The project TAG, the size, the model of the valve, the pressure rating, the model and type of the actuator, the valve Cv, and whether the valve fails open, closed, or in place.

D. Provide a detailed test plan describing the specific procedures used to complete and document the "Owner-witnessed Testing" described in the Final Acceptance requirement.

1. Test plans shall include a complete schedule for tracking each phase of the testing, e.g. zone testing by floor, fan testing by system, chiller interface testing, heating system testing, etc.

2. The vendor is required to supplement the planned work effort to meet the progress dates given in the schedule.
3. Provide printout of programming code.
4. Show initial setpoints.
5. Provide all documentation necessary to interpret programming related submittals.

E. As part of the submittal process, the vendors shall meet with representatives of the Owner's engineering and operations divisions, giving them a thorough briefing on the BAS programming design. This briefing shall describe in detail the methods the control programmer has used to meet the requirements of the description of operations.

F. Submit the point-to-point (PTP) and description-of-operation verification test plans at least 30 days prior to the scheduled beginning of testing. PTP testing shall be part of the construction schedule.

## 1.7 QUALITY ASSURANCE

A. All materials and equipment used shall be new, standard components, regularly manufactured and not custom-designed or fabricated specifically for this project.

B. All components and software shall have been previously tested and proven in regular use. Minimum in-use requirements are 24 months for hardware and 12 months for major software (whole number revision) releases.

C. Modularity. The HVAC control system shall possess a modular architecture, permitting expansion through the addition of more distributed processing units, input/output units, sensors, actuators, and operator stations.

D. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

E. 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.

F. Comply with ASHRAE 135 for DDC system components.

G. System Software: Update to latest version of software at Project completion.

H. Approval - Vendor shall submit and receive approval for all submittals including materials, floor plan, schematics, and programming prior to installation.

## 1.8 COORDINATION

A. Coordinate location of thermostats, carbon dioxide sensors, and other exposed control sensors with plans and room details before installation.

B. Coordinate supply of conditioned electrical branch circuits for control units and operator workstation.

C. Coordinate equipment with Division 26 to achieve compatibility of communication interfaces.

D. Coordinate equipment with Division 26, Section 260913, "Panelboards" to achieve compatibility with starter coils and annunciation devices.

## 1.9 FINAL ACCEPTANCE REQUIREMENTS

A. Provide corrected documentation to show changes made to correct deficiencies discovered during commissioning tests. Reassemble manuals and drawing packages to reflect corrected documentation records.

B. Drawings and software:

1. Submit shop drawings reflecting final “as-built” condition.

    a. Provide record drawings on AutoCAD 2024 or newer. Deliver two copies of data on two CDs without compression
    b. Provide 3 copies of reproducible record drawings.
    c. These record drawings shall accurately depict the final as-built conditions and shall be on Architectural/Mechanical backgrounds provided by the A/E.
    d. These drawings shall include accurate depiction of location of sensors and controlled equipment (motor starters, valves, chillers, dampers, AHUs, etc.)
    e. Insert one copy of applicable shop drawings, panel layout drawing, and points list at each enclosure’s documentation holder.
    f. Furnish one original set of application software on CDs. Disks shall bear the manufacturer’s label. Field copies are not acceptable. Application software includes operating system, controls application generation, graphic support, maintenance support and all other utilities provided in support of the installed system.

C. Operation and Maintenance (O&M) Manuals: Provide two paper copies of material required and five copies on CDs in MS Word format. Describe operation, maintenance and servicing requirements of the HVAC control system and associated equipment. Provide the following information in separate sections, each with an index.

1. Technical literature for all equipment, including catalog sheets, calibration, adjustments and operation instructions, and installation instructions
2. Hardware and software manuals, including information supplied by the original product developer, on the application programs and on the computers and controllers provided by vendor
3. System description and complete description of operation
4. Reduced size (11” x 17”) copies of record drawings
5. Input/Output (I/O) summary forms for the system, listing all connected analog and binary input and output functions and the number and types of points. Indicate spare input/output capacity
6. Completed point-to-point checkout plan used in Owner-witnessed testing, and the completed data sheets showing the results of the point-to-point testing.

D. Owner-Witnessed Testing

1. All parts of the testing described in this section are to be performed as point-to-point tests and control description verification. The Owner may choose to have this testing witnessed by a member of the Owner's staff, by an independent commissioning agent, by a member of the A/E team, or otherwise.

    a. One copy of the preliminary as-built documents shall be provided to support this testing.
    b. After receipt of all system documentation by the Owner, notify Owner 10 working days before testing begins.
    c. Testing shall be performed by the manufacturer or its local representative. The procedure for the test must provide a format for documenting the results, comments, vendor repair activity, vendor's initials, and retest witnessing. Provide data sheets with one line for each physical point on the system, and columns to record the results, dates, and initials of witnesses for both pretests and witness tests.
    d. The Contractor shall perform point-to-point pretests before the witnessed tests and shall fill out data sheets during pretests to demonstrate successful performance prior to witnessed tests.

E. Installation verification tests:

1. Verify operation, location, and identification of power sources, including circuit breakers and control power transformers.
2. Start/stop points: Issue start and stop commands from an operator station. Verify that controlled equipment responds appropriately and that the start/stop status is accurately reflected at the operator station.
3. Analog points: Analog inputs and outputs shall be verified at both extremes of their ranges and at the midpoint. Verify tight shutoff and full opening of dampers and valves.
4. Binary points: Verify that both commanded conditions (on/off, open/closed, etc.) are accurately reflected at the operator station.
5. Test fan and pump failure alarms by turning off the motor at the HOA switch and observing the run-state indication at the operator station.
6. Temperature points: Verify calibration of sensors by comparing displayed temperature values with the reading of an independent measuring device located in the same flow. Test liquid temperature sensors as installed in piping thermowells to verify effectiveness of heat conducting compound.
7. Pressure points: Verify calibration of sensors by comparing displayed pressure with the reading of an independent measuring device located in the same flow stream. Retain the services of the balancer as required to confirm readings.
8. Control valves: Verify tight shutoff by comparing water or air temperatures entering and leaving the heat transfer device.
9. Operator response and sequencing: Demonstrate that descripted or modulated valves and dampers position accurately in response to posit multiple operators to provide simultaneous modulation of parallel dampers or valve assemblies.
10. Control signal stability, general: Demonstrate that control loops are tuned so that the output does not change until the controlled system has had time to respond to the last output signal.
11. Control signal stability, response to step input: Demonstrate that control loops are tuned so that they are stable without excessive hunting following a step input of not less than 20% of the operating/reset range of the controlled variable.

12. Control signal stability, floating point devices: Verify that minimum pulse output duration is no less than the value required to assure repositioning of the controlled device.
13. Demonstrate the capability of the controls system to execute the complete description of Operation as given in the mechanical design documents.
14. Verify tight shut-off of all actuated control valves (for three-way valves, demonstrate capacity for 100% by-pass of coil).

F. Operator station tests:

1. Override test: Verify manual override capability for start/stop and modulated point types.
2. Control logic:

    a. Exercise all control logic packages.
    b. Check response to upset, change in setpoint.

3. Supervisory function:

    a. Verify content of time clock schedules.
    b. Verify alarm's reporting capabilities.

4. Failure modes:

    a. Verify all stand-alone operation by disconnecting communication lines between stand-alone control units and verifying continued operation.
    b. Disconnect and reconnect controller power to confirm proper recovery from power failure (sample).

G. Other software tests:

1. Trend logging
2. Report generation
3. Remote access
4. Test the ability of the control system to automatically restart all the connected systems following a power restoration and fire alarm recovery.

## 1.10 SERVICE AND GUARANTEE

A. The complete control system shall be warranted to be free of defects in manufacturing, workmanship, and materials for one year. Temperature sensor accuracy shall be warranted for three years. Software and documentation shall be revised to reflect system changes required to meet warranty obligations.

B. During the warranty period, provide emergency service telephone number where a qualified service technician, familiar with the installed system, may be reached and will respond within 12 hours.

1. This technician shall have the capability of remote communication with the control system for troubleshooting and program alterations.
2. The vendor shall pay all costs to provide communications for remote access.

3. A fully equipped, qualified repair technician shall be at the job site within four hours of a request for emergency service.

C. All replacement parts must be available on site within 48 hours during the term of the warranty.

D. Provide free of charge during the warranty period four DDC software sequence modifications (up to 24 hours engineering time) as instructed by the Owner. Modification shall be in software only.

## 1.11 POST-INSTALLATION TRAINING AND MATERIALS

A. The manufacturer and control contractor shall train operating personnel (FOMs) in the operation and maintenance of the system as follows:

1. The controls subcontractor shall provide the Owner's system operators complete training for proper control of the system under all modes of operation. These modes shall include but not be limited to summer/winter, energy management and alarm event description. The training shall be conducted during normal working hours, Monday through Friday at the job site. Training shall consist of both classroom and hands-on training. Provide a minimum of 16 hours of on-site training for a total of three people. Provide each trainee with a copy of the description of operations and the graphics during each training session. Training will be refined based on the successful bidder and may address the following subjects:

   a. Sensor/actuator operation.
   b. System architecture and basic theory of operation.
   c. Operator level (password level 1) interface to system for password access, alarm handling, point addressing, manual commands and statistical data acquisition.
   d. Program level (password level two) operation for command control and definition of energy management parameters.
   e. Configuration level (password level three) for all database entry and modification.
   f. Review of description of operations.
   g. System troubleshooting.
   h. Emergency service support.
   i. Fire alarm interface.
   j. System restart after power failure.
   k. Replacement procedures of each system component.
   l. Calibration and initialization procedures.
   m. Regeneration procedures on all installed programming at operator’s control stations.

2. Provide one each of the following:

   a. Complete reference materials (manuals) that would be used by a factory trained master technician
   b. Test instruments, and software manufactured or modified by the manufacturer for use in the installation, troubleshooting, and repairs of installed devices. Include unique portable test terminal, test boxes, circuit card extenders, calibration modules, etc.

3. The Owner will be allowed to video tape any or all the training sessions.

B. Provide all the training and materials that a control contractor service employee would receive in order to become a Master Technician. Training and materials will be provided for three Owner representatives on separate schedules. Provide a complete description of this training with the submittals. Include the cost of training, travel, lodging and transportation between lodging, airport, and training location.

## 1.12 SYSTEM COMMISSIONING

A. Provide assistance, staff, and materials to support the commissioning activities.

1. This includes all testing apparatus in use by the BAS contractor to test and calibrate or verify calibration of the control system.
2. Assistance includes but is not limited to reviewing test procedures and providing software enhancements to accommodate testing methods.

B. Provide staff and materials to support the point-to-point testing, also referred to as Owner-witnessed Testing and described under Final Acceptance Requirements.

C. Operate the control system for any commissioning tests specified in other specification sections.

## 1.13 DESCRIPTION OF OPERATION

See drawings M-601, M-602, M-603. Zone plan on sheet M-100.

# PART 2 - PRODUCTS

## 2.1 GENERAL

A. Provide as required for a complete and operating building automation system, all software, hardware, input/output devices, wiring and control power not shown in electrical bid documents, actuated dampers, actuated valves, actuators, operation and maintenance training, special maintenance tools and aids, supervision of labor, and warranty.

B. The system shall be built only of standard components kept in stock by the supplier.

1. All replacement parts shall be available on site within 48 hours.
2. The components shall not require customizing other than setting jumpers and switches, or adding firmware or software modules, or on-site software programming to do required functions.

C. System display should meet the following requirements:

1. The system is to be fully menu-driven.
2. All system titles, prompts, and instructions are to be in the English language.
3. All entries to be in natural units, i.e., a setpoint value shall be entered in its actual control unit of value, such as 74º F.
4. The primary means of information display and system management shall be by graphic display. Use the same style of display as is currently used throughout the facility.

5. Each display will contain comment sections to indicate area served (if area-specific) and contain a graphical presentation for all other interlocked systems.

## 2.2 BASIC SYSTEM FEATURES

A. Zone-by-zone control of space temperature, usage scheduling, and equipment failure reporting (A zone is the area served by one HVAC terminal unit, fan coil, heat pump, air terminal, etc.)

B. For all controllers and other devices that do not automatically and immediately resume normal operation after loss of power and then restoration of power, provide Werner Electric Stabiline UPS (Uninterruptable Power Supply) model SW1500 (or approved equal having five year battery life and battery hot swappable capability) for all cabinets having a mounting area over 120 square inches and containing controllers. These cabinets shall be provided with a fused duplex receptacle to be used a source for UPS power. Cabinet shall draw power from the UPS. Provide shelf for UPS.

C. Tamper-proof room wall mounted sensors installed with Allen, Bristol, or similar hardware with local temperature setpoint adjustment (limited range). The maximum allowed temperature range shall be set from an operator's station. Program the local control ranges as follows:

1. Standard thermostats - 70°F to 75°F
2. Mechanical and electrical rooms - 50°F to 85°F

D. Space temperature control in specifically identified locations will use return/exhaust duct mounted sensors and setpoint will be adjusted with computer interface.

E. Individually assignable priority password security system to prevent unauthorized use. Provide at least four levels including the following: Information only, change of setpoint & ON/OFF, programmer, and a fourth master level for assigning appropriate local access.

F. Equipment monitoring and alarm function including information for diagnosing equipment problems.

1. All system points shall be programmed to report alarm conditions by fully expanded point names that are tailored and specific to this project.
2. Assign alarm limits at 10% above highest expected level and at 10% below lowest expected level (subject to control description design) or as requested by Owner.
3. Interlock all alarm points to system status to lock out alarms when the system is not operational by schedule or operator command.

G. Auto-restart, without operator intervention, the operator stations and all controlled equipment to the control state that would be in effect if the power failure or fire alarm event had not occurred. Start/stop outputs shall continue to command the affected device while motor power is unavailable and allow for equipment restart, as previously commanded or scheduled, upon restoration of motor power.

H. Equipment run-time totalization of motor driven equipment.

I. Interactive displays of all input and output points: As a minimum, each of 200 screens on the monitor shall be able to display 25 interactive points and custom text.

J. Operator shall be able to, through keyboard interface, disable any control logic for any output or setpoint, temporarily substitute the value for any input/output, and introduce a different value or state for all inputs, outputs and setpoints.

K. Individual controllers shall be programmed with nonvolatile stand-alone control logic necessary to maintain appropriate HVAC equipment operation. While in temporary stand-alone mode, energy efficiency can be sacrificed to maintain temperature control and operational conditions that will not damage equipment or compromise health and safety.

L. Controllers shall, upon loss of valid programming, be capable of requesting and receiving a programming download of all required program code from the system management server.

M. Owner personnel shall be able to create and modify control software in any facility computer utilizing menu-driven programming. Owner personnel shall be able to store the programming on a removable computer disk and preprogram a nonvolatile, transportable memory storage device, which can be used for replacement of the programming in system controllers.

## 2.3 SYSTEM ARCHITECTURE

A. The BAS shall consist of a network of controllers providing full stand-alone operation of the building. The controllers shall contain the necessary programming to accomplish the description of operations for building control.

B. Controllers shall normally execute the control strategy to use peer-to-peer communication capabilities. Upon loss of communication, the stand-alone control unit shall be able to execute its own stand-alone programming. This distribution of control authority is mandated so that the lost communications capability shall not cause a complete loss of control for affected systems.

C. Operator station shall not be necessary to sustain building operation.

D. All EMCS equipment installed in this project shall be interoperable to interface with the existing campus EMCS. All control products provided for this project shall comprise a BACnet internetwork.

E. The Contractor shall provide all communication media, connectors, repeaters, hubs, and routers necessary for the internetwork.

F. All controllers shall have a communication port for connections with the operator interfaces using the BACnet Data Link/Physical layer protocol.

G. Communication services over the internetwork shall result in operator interface and value passing that is transparent to the internetwork architecture as follows:

1. Connection of an operator interface device to any one controller on the internetwork will allow the operator to interface with all other controllers as if that interface were directly connected to the other controllers. Data, status information, reports, system software, custom programs, etc., for all controllers shall be available for viewing and editing from any one controller on the internetwork.

2. All database values (e.g., objects, software variables, custom program variables) of any one controller shall be readable by any other controller on the internetwork. This value passing shall be automatically performed by a controller when a reference to an object name not located in that controller is entered into the controller's database. An operator/installer shall not be required to set up any communication services to perform internetwork value passing.

H. Dedicated Controllers: All sensing points and controlled outputs associated with a sub-system or piece of equipment shall be wired to and processed within one controller. A sub-system is defined as a group of equipment items that are directly controlled together, such as the components associated with an air handler. A “reset” signal may come from another subsystem controller. When supply terminal units are to be tracked by an exhaust terminal unit, all supply and exhaust monitoring and control points shall be processed by the same controller.

## 2.4 GRAPHICS

A. General: Provide complete graphics for all systems. Graphic completeness, appearance and quality shall be the best available from the approved manufacturer. All system shall be diagrammed in the graphics with measured values indicated at the appropriate location on the diagrammatic graphic. Setpoint, on-off-auto and similar adjustable shall be at the appropriate location on the diagrammatic graphic.

B. Graphic display requirements:

1. Provide a Microsoft Windows-based software package for the preparation of system graphics.
2. Include with this software a library of HVAC symbols such as fans, pumps, chillers, etc.
3. This section establishes standards for graphic displays as follows:

    a. All operator stations shall be programmed to display dynamic color graphic representations of the mechanical systems and floor areas for which this system has control.
    b. Systems to be displayed include the air handlers (including all monitored and controlled components), air terminal units, fans, chillers and towers, heat converters and exchangers, pumping systems and similar mechanical devices.
    c. Show the mechanical equipment components on a single graphic. Example: Chilled and condenser water pumps, cooling towers, chillers, differential pressure control valves, etc.
    d. Displays shall automatically update with current real time data.
    e. Room floor plan displays are required and shall indicate the approximate positions of controlled mechanical system elements.
    f. All displays shall show real time data to include temperatures, actuator positions, and motor run status.
    g. All system input, output and setpoint points shall be displayed on an appropriate graphic.

2.5 DDC EQUIPMENT

A. OPERATOR STATIONS

1. Local Access: Operator interface with the installed EMCS equipment and the entire campus BAS shall be performed with portable computers and desktop computers using site licensed software.
2. WEB Access: It shall be possible to interface with the EMCS via the internet web browser.

    a. Operators shall be able to access information through user interfaces at the application controller and the plant controller levels, as well as at the master display.
    b. System shall be an open, interoperable system supporting LonWorks®, BACnet® and/or other protocols.

3. Operator interface with the EMCS includes the ability to operate and program all campus EMCS equipment. The ability to look, adjust/override and program will be controlled using access levels.
4. Overall management of the EMCS, storage of programs, data, trends, access control, graphics.
5. Application Software:

    a. I/O capability from operator station.
    b. System security for each operator via software password and access levels.
    c. Automatic system diagnostics; monitor system and report failures.
    d. Database creation and support.
    e. Automatic and manual database save and restore.
    f. Dynamic color graphic displays with up to 10 screen displays at once.
    g. Custom graphics generation and graphics library of HVAC equipment and symbols.
    h. Alarm processing, messages, and reactions.
    i. Trend logs retrievable in spreadsheets and database programs.
    j. Alarm and event processing.
    k. Object and property status and control.
    l. Automatic restart of field equipment on restoration of power.
    m. Data collection, reports, and logs. Include standard reports for the following:

        1) Current values of all objects.
        2) Current alarm summary.
        3) Disabled objects.
        4) Alarm lockout objects.
        5) Logs.

    n. Custom report development.
    o. Utility and weather reports.
    p. Workstation application editors for controllers and schedules.
    q. Maintenance management.

6. Custom Application Software:

    a. English language oriented.
    b. Full-screen character editor/programming environment.

c. Allow development of independently executing program modules with debugging/simulation capability.
d. Support conditional statements.
e. Support floating-point arithmetic with mathematic functions.
f. Contains predefined time variables.

B. 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 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.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.

C. 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.

D. 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.

5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (four to 20 Ma).
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.

E. 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 one 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 three seconds without failure.

F. 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.

## 2.6 UNITARY CONTROLLERS

A. Each controller shall operate as part of the control system and as an independent unit when not in communication with other controllers or an operator station. Global controllers shall be able to share Global information on a peer-to-peer basis without relying on an operator station.

B. It shall be possible to define control strategies at each controller from any operator station. Each controller shall be able to interface directly with an operator station.

C. Each controller shall include its own microprocessor, power supply, and, if necessary, battery with automatic charger. Upon loss of system power, the controller memory shall be maintained for a minimum of 72 hours with no external source of power. Upon restoration of system power, the control unit shall resume full operation without operator intervention.

D. Provide control programming logic at each controller for proportional and/or proportional plus integral control capabilities as necessary to assure complete and stable control of each controlled variable.

E. Each controller shall maintain and perform its own stand-alone control strategy upon communications failure. The controller stand-alone control program shall be adequate to maintain the basic control function and provide protection from inappropriate equipment operation. The controller shall retain its programming during a power failure and resume operation without program reloading from another device.

F. The controllers shall be powered by 24 VAC.

G. Each controller shall be isolated (optically or by other means) from communication trunk and have fuse or overload protection.

H. The controller point monitoring and control capabilities shall include but not be limited to the following as required to accomplish specified sequence of operation:

1. Binary inputs (contact closures)
2. Analog inputs (use only resistive, 0-10 volt, and 4-20 ma. inputs; provide A/D conversion of 10 bits, minimum)
3. Binary output (start/stop or latching and momentary contacts)
4. Floating point control
5. Analog outputs (must include 4-20 ma. @ 10 VDC minimum, 0 -10 VDC; provide A/D conversion of 12 bits, minimum).
6. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.

## 2.7 ALARM PANELS

A. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish.

B. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.

1. Alarm Condition: Indicating light flashes and horn sounds.
2. Acknowledge Switch: Horn is silent and indicating light is steady.
3. Second Alarm: Horn sounds and indicating light is steady.
4. Alarm Condition Cleared: System is reset and indicating light is extinguished.
5. Contacts in alarm panel allow remote monitoring by independent alarm company.

## 2.8 ALARM PROGRAM

A. For each alarm input, provide the following assignable alarm responses:

1. Display English language point description in addition to system point identification.
2. Print out alarm description and operator-created alarm message.
3. Require acknowledgment by operator and print occurrence if directed by Owner.

## 2.9 LOGS

A. Trend log: As a minimum, provide capacity for 50 trend logs. Provide for review of data on monitor and printer. Each trend log shall have assignable start/stop times/dates.

B. Current alarm log: Display all points currently in alarm. Operator activity log: Record operator activity by operator account identification and work performed during a minimum of the last 10 log-in sessions or last 20 commands.

## 2.10 ANALOG CONTROLLERS

A. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.

B. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range minus 10 to plus 70-degree F, and single- or double-pole contacts.

C. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.

D. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of 3 to 13 psig.

## 2.11 FAILURE MODE

A. Upon failure of any global controller, the operator station shall display off-line occurrence for each affected point and provide communication verification to each controller for each I/O channel.

B. In the event of communication failure, controller shall continue to operate equipment using appropriate backup values for missing global information. If sensor information is necessary for proper stand-alone function, then that sensor shall be attached directly to the appropriate controller. Provide failure mode programming to accomplish safe operation of equipment in case of communications failure on local trunk.

C. Upon return of primary power after a power failure of up to 72 hours, the system shall automatically return to completely normal operation with no action required from operating personnel.

D. Unless otherwise indicated in the design documents, provide the following failure modes, (that is, the position that the controlled device attains under failure due to loss of power, loss of air pressure, or loss of communications) for valves and dampers:

1. All Fan cooling water valves shall fail closed.
2. All central cooling water differential pressure control valves shall fail closed.
3. All fan exhaust air and outside air dampers shall fail closed.
4. All fan recirculation dampers shall fail open.
5. Zone-level air terminal unit dampers may fail in place.

## 2.12 ENERGY REDUCTION AND SPECIAL OPERATION SOFTWARE

A. The system shall be designed to control energy-consuming loads. Provide engineering, consulting, and programming to develop and set up the following energy reduction software:

1. Time schedules: Software should provide at least 16-time schedules. Each schedule is to be an 8-day type, capable of six entries minimum per day. Time program shall provide ON/OFF commands and reset SETPOINT capabilities.
2. Holiday time programs: Provide a holiday time schedule capability.
3. Optimal start/stop: Provide the ability to optimize start/stop times to attain and maintain temperature setpoint only during occupied times. The system shall be self tuning, with compensation for weekends and holidays.
4. Setpoint reset: Provide a means of automatically resetting heating water, chilled water and ventilation air temperatures, volumes, and pressures.
5. Provide a program to automatically restart all DDC controlled equipment upon the resumption of power or return from fire alarm condition. Equipment shall be restarted according to a prearranged, prioritized, and staggered restart schedule.
6. For loads that have been turned off at the Motor Control Center, either by positioning of the HOA switch or the line disconnect; provide a restart strategy that automatically restarts load upon the reset of switches to their normal on-line positions.
7. Provide capability to adjust the setpoints of main mechanical systems from an operator station using simple ‘point and click’ command windows.

## 2.13 ELECTRONIC SENSORS

A. Temperature sensors:

1. Sensors shall be completely precalibrated with no electrical adjustments or calibration required for standard installation conditions.
2. The temperature displayed at an operator station shall be accurate to within 1º F. This accuracy shall be warranted (parts and labor) for a minimum of three years.
3. Wall-mounted sensors shall be tamperproof. Wall mounted sensors for zone controls shall provide jack for operations laptop connection. That connection shall allow communication with system for monitoring and adjusting at least the zone-level equipment serving that zone. Wall sensors shall include temperature readout and shall provide basic control description diagnostic and reset features and local setpoint adjust and after-hours override
4. Freeze protection sensors shall be non-averaging.
5. Thermowells shall be bronze, brass, or stainless steel with 1-inch NPT threads.
6. Install piping temperature sensors adjacent to temperature gauge or test port.

    a. Use heat-conducting compound in thermowells.
    b. Strap-on fluid temperature sensors will not be allowed.

7. Mount outside air sensors inside the outside air intake as to avoid solar influence and directly sense the average temperature of the air entering the air handling unit(s).

B. Air velocity transmitter: Shall provide air velocity information independent of the effects of static pressure. Transmitter shall operate at rated accuracy from 0º F to 120° F. The minimum accuracy of displayed value at an operator station shall be 95% through the range of 20% to 100% of sensed airflow, with a drift rate no greater than one percent per year. The proportional output shall be 4 to 20 ma.

C. Differential and static pressure transmitter: Transmitter shall operate from 50% of minimum to 150% of maximum anticipated pressure. The maximum error of displayed value at an operator station shall be 2% through the range of 20% to 150% of the intended maximum setpoint. Minimum pressure tolerance shall be 150% of the maximum pressure expected in normal operation. The maximum drift rate shall be no greater than one percent per year. The proportional output shall be 4 to 20 ma. Provide designed pressure pitot sensor Dwyer type A-301/A 302 or approved equal.

D. Current sensors shall convert AC to proportional DC (4 to 20 ma). Response time: 300 milliseconds to 99% of final value. Manufacturer: Neilson-Kuljian or approved equal. Controls will be programmed to indicate equipment failure if motor current goes above or below normal conditions.

E. Averaging elements shall be mounted to cross a minimum of 80% of the plenum width and shall be located to provide an indication of temperature within +/- 1° F. Provide support at 36 inches maximum such that there will be no metal to metal contact between the sensing element and other equipment.

F. Outside air sensors shall be a waterproof assembly protected from solar radiation. Span shall cover the range of 0º F to 100° F or better and not exceed a 150° F span. Typically, mount sensor inside an outside air intake that draws air 24/7.

G. Pressure Transmitters/Transducers:

1. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

    a. Accuracy: Two 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).
    e. Manufacturer:

        1) Tek-air Systems Inc., Ultra low series
        2) Setra Systems
        3) Veltron
        4) Modus “low flow T” series
        5) Ultratech Inc.

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. Manufacturer:

   a. Tek-air Systems Inc., Ultra low series
   b. Veltron
   c. Modus `low flow T' series
   d. Ultratech Inc

5. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.

## 2.14 STATUS SENSORS

A. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of 0- to 5-inch wg.

B. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of 8 to 60 psig, piped across pump.

C. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

D. Voltage Transmitter: Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and one percent full-scale accuracy.

E. Power Monitor: Three-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.

F. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

G. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

## 2.15 THERMOSTATS

A. Thermostats shall be low-voltage, thermistor sensor, touch screen operated, with 55 to 85-degree F set-point range, minimum. Thermostats shall be programmed so the user can adjust temperature higher or lower a pre-determined range (coordinate range with owner). A 5-degree dead band between heating and cooling shall be programmed.

## 2.16 ELECTRONIC AIRFLOW MEASUREMENT STATIONS:

A. Ebtron Model GTC116 or approved equal. Thermal dispersion airflow measurement. UL listed, airflow accuracy +/- 2% of reading, 6063 gold anodized aluminum probe, 304 ss brackets, RS-485 output with BACnet MS/TP.

B. General

1. Provide one airflow measurement device (AMD) for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location.
2. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes.

    a. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.

3. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate.

    a. Actual airflow rate calculations shall have the capability of being adjusted automatically by the transmitter for altitudes other than sea level.

4. Temperature measurement shall be field configurable to determine the velocity weighted temperate or simple arithmetic average temperature.

C. Sensor Probes

1. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube. Insert 316 stainless steel tube in lieu of 6063 aluminum alloy tube, when required.
2. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
3. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.

    a. PVC jacketed internal wiring is not acceptable.

4. Probe internal wiring connections shall consist of solder joints and spot welds.

    a. Connectors of any type within the probe are not acceptable.
    b. Printed circuit boards within the probe are not acceptable.

5. Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
6. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392°F and continuous and direct UV exposure.

    a. Plenum rated PVC jacket cables are not acceptable.

7. Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
8. Each sensor probe shall contain one or more independently wired sensing nodes.
9. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
10. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy.

a. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.

11. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
12. Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
13. The number of independent sensor nodes provided shall be as follows:

| Area $ft^2$ | # Sensor Nodes |
|---|---|
| ≤ 0.5 | 1 |
| > 0.5 & ≤ 1 | 2 |
| > 1 & ≤ 2 | 4 |
| > 2 & ≤ 4 | 6 |

| Area $ft^2$ | # Sensor Nodes |
|---|---|
| > 4 & ≤ 8 | 8 |
| > 8 & ≤ 12 | 12 |
| > 12 & ≤ 14 | 14 |
| > 14 | 16 |

a. A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 $ft^2$.

D. Transmitter

1. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
2. The transmitter shall be comprised of a main circuit board and interchangeable interface card.
3. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
4. All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
5. All receptacle plug pins shall be gold plated.
6. The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes.

   a. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).

7. The transmitter shall be capable of providing a high and/or low airflow alarm.
8. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
9. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.

   a. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.

10. The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus RTU) network connection.
11. Analog output signals shall provide the total airflow rate and be field configurable to output one of the following:

    a. temperature
    b. airflow alarm; or
    c. system status alarm

12. Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
13. Provide an infra-red I/O card mounted on the transmitter PCB for communication to a handheld retrieval device that can download individual sensor node airflow and temperature data in real time.
14. The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
15. The transmitter shall use a "watchdog" timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

E. Performance

1. Each sensing node shall have an airflow accuracy of ±2% of reading over an operating range of 0 to 5,000 FPM.

    a. Accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
    b. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.

2. Each sensing node shall have a temperature accuracy of ±0.15° F over an operating range of -20°F to 160°F.

F. Listings and Certifications

1. The AMD shall be UL873 Listed as an assembly.

    a. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.

2. The AMD shall be BTL Listed.
3. The AMD shall carry the CE Mark for European Union Shipments.

## 2.17 ROOM DIFFERENTIAL PRESSURE SENSORS

A. Basis of design product is Differential Pressure Transducer by a Setra Systems, Inc. Model 264

1. Capacitive based sensor using a stainless-steel sensor.
2. Ability to measure air pressure ranges as low as 0-0.25 inches w.c. bi-directional with a resolution of 0.001" WC.
3. The differential pressure sensor must have the ability to send an analog output of 4 to 20 mA (2-wire) to a system controller.
4. Must be temperature compensated to 0.033% FS thermal error over the temperature range of 0°F to 150°F.
5. Must be reverse wiring protected.

## 2.18 ACTUATORS

A. Actuator type: Electronic actuators shall be used for all water control valves and air dampers.

B. Electronic actuators shall be Belimo, Delta, or approved equal selected from the vendor ‘s standard product line.

1. Sized for torque required for damper seal at load conditions.
2. All electronic actuators shall be powered by 24 VAC (smoke damper are powered by 120 volts as per specification 233300).
3. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
4. Proportional electronic actuators shall use 0 to 10 VDC, 4 to 20 ma. or floating-point control.
5. Floating point actuators shall have position indicated by potentiometer so the control system will always know exact position.
6. Temperature Rating: Minus 22 to plus 122-degree F**,** (Minus 22 to plus 250-degree F for smoke dampers).
7. Multiple electronic actuators may be powered by one separately fused 24 VAC transformer, providing the transformer size does not exceed 100 VA.
8. No more than two electronic actuators may drive a common shaft.
9. All electronic actuators shall have field manual positioning capability to allow manual positioning of valve or damper in absence of control power.
10. Two integral built-in auxiliary end switches.
11. Actuator shall have positioning feedback.

C. Actuators shall be capable of providing 150% of the minimum valve or damper manufacturer’s published torque requirements for complete shutoff.

D. Actuators shall ‘Fail in Last Position’ unless otherwise noted.

E. Valve actuators shall have clutch and manual positioning handle/wheel at all locations where a separate isolation valve is not provided immediately adjacent to the controlled valve.

## 2.19 CONTROL VALVES

A. Control valves shall be selected to meet CV and pressure requirements.

1. Two-way pressure independent water control valves shall be sized for a pressure drop of approximately 3 psi. Higher pressure drop shall be provided if allowed or directed by the A/E (during shop drawing review) where branch pressure to a controlled equipment is felt to be significantly more than the equipment pressure drop.
2. Three-way water control valves shall be sized for a pressure drop of approximately 2.5 psi.
3. Steam valves for equipment having condensate draining to near-atmospheric pressure shall be sized for a pressure drop of approximately 50% of the normal steam supply pressure.
4. Valve body and actuator selection shall be sufficient to handle system pressure and shall close against the system differential pressures.
5. Valve service rating shall be 125 psig. or greater.
6. The shafts to which the actuators are coupled shall be square or hexagonal or round with one side flattened to insure tight coupling.

7. Install valves in the orientation recommended, or stated as preferred, in manufacturer's literature.

B. Provide valves with rotating control stems except where "lift and lay" valves are specifically identified. Use the following valves unless they are unsuited for a specific application:

1. Use Belimo or Delta characterized ball valves with actuators for sizes ranging from ¼" to 2" full port. Where valves are for open-close application only, the "characterized" feature shall not be provided, provide full port size.
2. Zone valves: Valves shall be constructed with a cast brass body and stainless-steel balls. The valve shall provide for 100% shut-off and silent operation.

C. Use butterfly valves when characterized ball valves do not provide necessary CV. Butterfly valves with disks attached to the stem with screws, bolts or rivets are not acceptable. Use Demco, Victaulic or approved equal. Butterfly Valves: 150-psig 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.

D. Steam valves shall be Siemens 599 or approved equal.

E. Hydronic system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. NPS 2-1/2 (DN 65) and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
3. Internal Construction: Replaceable plugs and stainless-steel or brass seats.

    a. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    b. Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.

4. Sizing: 5-psig maximum pressure drop at design flow rate or the following:

    a. Two Position: Line size.
    b. Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    c. Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.

5. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
6. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

F. Steam system globe valves shall have the following characteristics:

1. NPS 2 (DN 50) and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
2. Internal Construction: Replaceable plugs and stainless-steel seats. Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
3. Sizing: For pressure drop based on the following services:

    a. Two Position: 20 percent of inlet pressure.
    b. Modulating 15-psig Steam: 80 percent of inlet steam pressure.
    c. Modulating 16- to 50-psig Steam: 50 percent of inlet steam pressure.
    d. Modulating More Than 50-psig Steam: As indicated.

4. Flow Characteristics: Modified linear characteristics.
5. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.

G. Self-Contained 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 and 250-degree F operating conditions.
2. Thermostatic Operator: Liquid filled remote sensor with integral adjustable dial.

## 2.20 DAMPERS

A. See Section 233300 - Air Duct Accessories.

## 2.21 VARIABLE FREQUENCY DRIVES (VFDS)

A. VFDs for division 23 equipment shall be provided by the controls system subcontractor as per section 230915.

B. Division 26 contractor shall install field mounted VFDs and provide power wiring to the VFDs and from the VFDs to their controlled motors.

C. The controls system subcontractor shall provide control wiring for VFDs. Division 26 contractor shall provide power to factory mounted VFDs once they are installed in the field.

## 2.22 ENCLOSURES

A. All enclosures to be NEMA 1, unless otherwise required for intended service. All controls and instruments shall be logically assembled at one or more panels, have hinged doors, and be marked with engraved melamine labels.

B. All enclosures used as a mounting site for control devices shall also contain a documentation holder located on the inside of the door.

C. All enclosures shall be provided with locks.

D. Label each equipment panel furnished with 120 VAC power with power source label showing identification of power panel and breaker.

2.23 WIRING AND CONDUIT

A. Install wiring and conduit in accordance with Division 26 requirements.

B. Minimum wire size shall be based on the manufacturer's recommendations based on the specific application. Single conductor wire insulation shall be THHN. All wires shall be sized in accordance with the NEC for the load serviced. A single conductor shall not be used for more than one leg of an input or output device circuit (no "common" conductors) unless approved by Owner.

C. All wiring shall be stranded. Exceptions will be made for wiring used in preassembled factory crimped cables, 20 g and smaller, where connectors provide support to the insulated cable jacket at the point of connection.

D. All low voltage energy limited wiring (except 24 VAC power), installed in open tray or installed as open wiring, shall be in jacketed cables dedicated to individual devices.

E. Junction box covers shall be labeled "DDC" or show the vendor logo.

F. Splicing shall be minimized and shall be done only in accessible outlet, junction, or cabinet boxes that are clearly shown on the "as-built" record drawings. Splicing shall be made with 3M "Scotchloc" spring connectors with steel cap and PVC insulation, Thomas & Betts, or a crimp on butt-splice, or approved equal. When splicing is necessary, the insulation colors shall match, and the conductors shall be mechanically secured to each other so that no stress is applied to the splice. Splicing of long runs shall be accomplished by means of a fully insulated crimped barrel connector.

G. Wire pulls by powered mechanical means will not be permitted. Conduit shall be cleaned of foreign material just before pulling the wire or cable. Lubricants shall be compounds specifically prepared for cable pulling and shall not contain petroleum or other products that will affect cable insulation.

H. Wire that has scrapes, nicks, gouges, or crushed insulation shall not be used and shall be removed when present.

I. Groups of conductors, where installed in cabinets and wire trays, shall be neatly grouped with wire ties or equal.

J. All wiring contained in metal wireways shall be in wireways dedicated to low voltage service.

K. Low voltage energy-limited wiring shall not be run in the same wireways with, or closely parallel to, high voltage or switched power wiring. Interposing relays shall be used for all switched power loads and shall be located so that the switched power conductors do not run in the same wireway as the interposing relay coil power or any other energy-limited low voltage conductors.

L. All wire shall be new and brought on the jobsite in original packages bearing Underwriter's label and the date of manufacture.

M. Aluminum wire is prohibited.

N. No conduit shall be filled so that the maximum bundled cross-sectional dimension exceeds 40 % of conduit inside diameter. No raceway shall be filled to more than 40% and maximum fill for "wiremold" (surface raceway) shall be 20%.

O. No wire run or circuit shall be longer than 80% of the maximum allowable length or power consumption for the wire size and application. No output circuit shall exceed 80% of the maximum load capacity specified by the manufacturer.

P. Wiring and conduit shall comply with Division 26 specifications.

1. The basic wiring method shall be in conduit unless otherwise permitted in this section.
2. Where conduit direct connection is not possible, all permitted open wiring shall be plenum rated.
3. Permitted open wiring is limited to the following applications:

    a. Wiring from a zone airflow control unit to a nearby temperature sensor not to exceed 50 feet
    b. Wiring from a zone airflow terminal control unit to a nearby water control valve not to exceed six feet

Q. Wiring from any controller to a device which has otherwise been approved for installation and cannot accept conduit connection shall meet the following requirements:

1. Conduit shall be used to within 12 inches of the device.
2. Install in wireway all trunk communication wiring between the operator station and the controllers, and between controllers. Open wiring is not otherwise permitted.

R. Conduits shall be provided with appropriate bushings and end fittings to protect cabling from sharp conduit edges.

S. Conduit size shall be ¾-inch minimum for all wiring groups consisting of six or more conductors. NEC requirements shall apply as though conductors were used to their full current carrying and thermal capacity.

T. Wireway runs shall be level, plumb, parallel, or perpendicular to walls, pipes and sides of openings. Wireways shall follow the contours of the support surface. Passageways for access and servicing shall not be blocked.

U. All wiring between global controllers and trunk, N2 and LAN cables longer than 300 feet shall be 100% backed up with spare conductors.

V. All conductors that become bundled or pass from an enclosure shall be identified with typed or machine lettered labels, Briade or approved equal. Tag numbers shall agree with wire numbers assigned on wiring diagrams and the installation drawings.

W. Wires shall be labeled with mechanically prepared labels at their connection point to each apparatus point of connection.

X. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls and for final connection to equipment.

Y. Open wiring, when permitted, shall be installed in compliance with WAC 296-46-725 with reference to NEC 336-15 and shall also be installed as follows:

1. All open wiring that penetrates through walls and crosses structural ceilings shall do so within 18 inches of the structural ceiling surface.
2. Wiring shall be attached to vertical supports at attachment points prepared by a protective wrap of electrical tape around the support. This wrap shall create a surface free of sharp edges.
3. Absolutely no wire is to be attached to pipe work or conduit of any kind.
4. Wire ties, if used, shall be trimmed to reduce sharp edges.
5. The vendor shall provide required cabling attachment points for control's use if the ceiling structure does not provide acceptable attachment points.

## 2.24 CONTROL RELAYS

A. Panel relays shall be plug-in type with contacts rated at twice the amperage rating of circuit requirements: Minimum temperature range –25º C to +70º C. Enclosure: Clear dust cover and shock resistant, rated for minimum of 2.5 million mechanical operations and 100,000 electrical operations at full load.

B. Remote/interposing relays shall be used for all remote switched loads.

1. They shall be housed in a NEMA-rated enclosure. Where two or more relays are mounted in the same enclosure, provide a hinged cover.
2. Besides meeting panel relay requirements, relays shall have 24 VDC coils and form C dry contacts with a minimum rating of 5 amperes @ 240 VAC.
3. Relays controlling inductive loads shall be equipped with coil transient suppression devices to limit transients to 150% of rated coil voltage.

## 2.25 TRANSFORMERS

A. 120V AC to 24V AC transformers shall be supplied to provide control voltage to the control system. The incoming 120V AC power shall be fused. Transformers shall be supplied with suitable mounting plates and mounted in separate electrical panel boxes with hinged covers adjacent to control system panels.

## 2.26 SPARE PARTS

A. Replacement Materials: Provide one replacement for each unique controller, damper motor, valve motor, thermostat, relay, etc.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS.

A. General: All work under this section shall be a subcontract by an authorized agent of the manufacturer.

B. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to description of operation.

C. Notations at Instruments: A typewritten notation shall be provided at each instrument stating its use; at thermostats, the proper setting. In finished spaces these notations shall be secured to the inside of the case; in other areas, shall be secured by adhesive to the duct or other adjacent surface and shellacked over. Instruments and equipment, whose use is self-evident, such as ordinary room thermostats, radiator valves, or similar unitary equipment valves, will not require such notations.

D. Penetrations of Ducts: All penetrations shall be properly sealed to prevent leakage around the opening; shall include a stuffing box type of closure or similar approved method.

E. Pipe Wells: Provide pipe wells for insertion of temperature sensors in water lines. Temperature sensing wells shall be of sufficient length to reach midway into pipe, with extension necks where installed or insulated piping. Wells shall be brass or stainless steel; installed in lines using tees or thread-o-lets.

F. Insertion Thermostats: Provide for all duct and water temperature sensing; capillary connected if averaging bulb type; capillary or rod and tube type for other units; nonbleed; throttling range as required for service; on water circuits, separable socket type; remote readjusting type where specified, adjustable ratio, straight line action, adjustable limit stops.

G. Wall mounted temperature sensors shall be mounted on electrical boxes, and all wire penetrations shall be sealed to prevent thermal convection.

H. It is the responsibility of the controls vendor to ensure that all sensors are placed in the measurable flow path to accurately measure the sensed variable. As a minimum, water flow sensors shall be installed with a straight section of piping 10 diameters upstream and four diameters downstream.

I. Sensors installed for outside air measurement and pressurization shall be located to optimize the accuracy of the measurement. Coordinate with Mechanical Consultant.

J. Valve operators shall be installed directly above the controlled valve whenever possible (with the exception of steam control valves where actuator is rotated to about 30 degrees to avoid hot zone directly above valve) unless rotation is needed to permit maintenance access. However, in no case shall the operator be rotated to or beyond horizontal.

K. All devices shall be mounted within enclosures. Cable trays and external cabinet surfaces shall not be used as mounting surfaces. Proof of run for both fans and pumps shall be by current sensing devices rather than differential pressure switches.

L. All pressure indicating/measuring devices shall be installed with capped tee devices to permit attachment of test meters.

M. Controls Mounting: Controls shall be grouped by systems, areas, or other appropriate basis concealed in locking-type wall-mounted cabinets, with proper labeling as to functions and settings marked on the front thereof, located no more than 6'-0" above the floor unless specifically approved by Owner. Control cabinets shall not be installed on ductwork or plenum walls. Mount all relays, switches, contacts, etc., in common panels. Tag each instrument by use of approved labels corresponding to symbols used on control drawings.

N. Location of Room Sensors: Where sensors are mounted at light switches, locate on centerline of the electrical outlet box, as directed. Sensors shall not be located above dimmer switches. Exact location of sensors shall be verified with final casework and furniture layouts.

O. Verify location of thermostats, CO2 sensors and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches or 60 inches above the floor. Install averaging elements in ducts and plenums in crossing or zigzag pattern.

P. Install automatic dampers according to Division 23, Section 233300, "Air Duct Accessories."

Q. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

R. Install labels and nameplates to identify control components according to Division 23, Section 220550, "Identification for HVAC Piping and Equipment."

S. Install hydronic instrument wells, valves, and other accessories according to Division 23, Section "Hydronic Piping."

T. Install steam and condensate instrument wells, valves, and other accessories according to Division 23, "Steam and Condensate Heating Piping."

U. Install duct volume-control dampers according to Division 23 Sections specifying air ducts.

## 3.2 CONTROL SOFTWARE PROGRAMMING

A. Control of equipment as described in the description of operations and shall include:

1. Time and holiday schedules
2. Alarm limits and histories
3. Summary of data for each zone
4. Trend logs and historical data
5. All setpoints
6. Master menu
7. Dynamic color graphic Interface

B. The following Points Descriptions of Operation shall be enhanced as necessary and included as part of the control drawings to expand and clarify information shown in the drawings.

1. Points information shall be displayed and organized by system in dynamic graphic form at the operator stations.
2. The energy reduction software and miscellaneous functions shall manage all points.

3. It shall be possible to “disconnect” any output or setpoint from the AUTOMATIC control logic and enter a MANUAL value or state from any Operator Station.
4. It shall be possible to replace any input with a MANUAL value from any Operator Station.
5. All control loop parameters for each loop shall be displayed on one display.

C. Where a point or device is indicated on a drawing, it shall be provided even if not required in a Description of Operation (Description). Where a point or device is required for a description, it shall be provided even if it is not shown on a diagram or plan.

D. All setpoints indicated in the descriptions are suggested initial setpoints. Actual setpoints shall be determined and programmed during system balancing and commissioning process. If actual setpoint determined during this process is substantially different from the initial suggested setpoint, request confirmation of acceptability from the A/E.

E. All setpoints and values indicated in the descriptions shall be adjustable with authorized access. Owner shall determine/confirm the appropriate access level during Owner training. It shall be possible to have multiple access levels with limited range of adjustability for each level.

F. All descriptions shall apply when the Operator (with proper access) allows automatic control via an Operators Station. It shall be possible to override to prevent automatic operation and take manual control of any system or equipment item. If automatic start-stop operation is not discussed in description for a particular device, then there shall be a manual “on-off” command feature at the Operators Station.

G. Displays: Every control device indicated on the drawings or specifications and every point required in the descriptions of operation shall have information displayed at the Operators Station(s). All information displayed shall have a simple and concise description of what the information is and means. Certain display requirements are indicated in the descriptions. To avoid unnecessary duplication, other more typical display requirements are <u>not</u> indicated in every description but shall be provided for every device or point as follows:

1. Every device or equipment item that has a start-stop, open-closed, on-off or similar binary output from the BAS shall have an operational status display. Display shall include multiple pieces of information, as follows:

   a. Current “on-off” command from EMCS
   b. Current “on-off” condition as sensed by proof switch (where available).
   c. Virtual “on-off” condition if a proof switch is not available, but other sensors can provide a reasonable verification of equipment operation. For example, such a reasonable verification may include using an analog pressure sensor downstream of a fan where a sensed value above a certain level could only occur if the fan was in operation.
   d. Indication as to if control is in automatic mode (controlled per description) or in manual mode.

2. Every device or equipment item that has a binary (open-closed contact) input to the BAS shall have an operational status display. Display shall include:
3. Current condition.
4. Every device or equipment item that has an analog control output from the BAS shall have an operational status display. Display shall include multiple pieces of information, as follows:

a. Current setpoint.
b. Commanded output (percent of maximum).
c. Display of the measured value at the controlling sensor or VFD.
d. Indication as to if control is in automatic mode (controlled per description) or in manual (override) mode.

5. Every device or equipment item that has an analog input to the BAS shall have an operational status display. Display shall include:

   a. Current measured condition.
   b. Whether alarm feature is active.
   c. Current setpoint for high and low alarm conditions.

6. Unless indicated otherwise in the descriptions, all stated values shall be assumed to use units of measurement displayed (at operator workstations) as follows:

   a. Temperature in degree F.
   b. Humidity in relative humidity (percent).
   c. Air pressure (and differential pressure) in inches water column.
   d. Water or steam pressure (and differential pressure) in PSIG.
   e. Water flow rate in GPM.
   f. Air flow rate in CFM.
   g. Speed as percent of maximum RPM (when motor is driven at 60 hertz by VFD).

7. The following points shall be displayed using calculated values based upon commanded position unless exact values, as indicated by a feedback signal, are required by control strategy:

   a. Fan speed (per cent of full speed)
   b. Damper positions (per cent of full open)
   c. Heating and cooling valve position (per cent of full open)

H. Trend Logs: Provide trend log programming and setup for individual points as requested by the Owner up to a maximum of three percent of all inputs provided on the project.

I. Alarms: Certain special alarm requirements are indicated in the descriptions. To avoid unnecessary duplication, all necessary alarm requirements are not indicated in every description. In addition to the listed alarms, every point shall be equipped to (potentially) have the following alarms. Each alarm shall include specific text (on screen) describing the nature of the alarm, and the source of the alarm information (such as “current sensing relay”, “differential pressure switch”, etc.) Each point shall be capable (with only programming and setup required) to alarm as follows:

1. Every device or equipment item that has a start-stop, open-closed, on-off or similar command from the BAS shall have an alarm to identify failure to operate as commanded. This alarm shall use available proof switches or other sensors that can be used as a “virtual proof”. Provide suitable delays to accommodate equipment startup times, etc.
2. Every device that has a binary (open-closed) input to the BAS that would normally be used as an alarm or service-requirement indicator (such as a differential pressure switch at a filter) shall provide suitable alarm annunciation.

3. Every device or equipment item that has an analog control output from the BAS shall have an alarm to identify failure of system to maintain setpoint at the controlling sensor. Provide suitable delays to accommodate equipment startup times, etc. Establish reasonable high and low condition alarm trigger points to accommodate normal and reasonable variations in system output.
4. Every VFD shall have an alarm contact monitored by the EMCS to acknowledge any faults. It shall also have an additional alarm contact monitored by the BAS to acknowledge if it is in the bypass mode.

J. Alarm Programming: Provide alarm programming and setup for all alarms specifically indicated in the descriptions of operation, and at additional points as requested by the Owner up to a maximum of 20% of all inputs provided on the project. Assign operator high and low alarm limits according to design data or as Owner requests. It is assumed that Owner will want alarms to be set up for all filter switches and at all inputs indicated, but not addressed in the descriptions.

K. Additional Control Requirements: Auxiliary Air Conditioning Units: Provide all control work required for all auxiliary air conditioning units. Include field wiring for any remote devices provided with each unit. Systems shall be controlled per manufacturer's recommendations and as follows: Provide DDC temperature sensor except where sensors are furnished with equipment.

## 3.3 ELECTRICAL WIRING AND CONNECTION INSTALLATION

A. All electrical control wiring and terminations for the control system shall be provided by the controls subcontractor,

B. Install raceways, boxes, and cabinets according to Division 26, Section 260533, "Raceway and Boxes for Electrical Systems."

C. Install building wire and cable according to Division 26, Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

D. Install signal and communication cable according to Division 27, Section 271500, "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.

E. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.

F. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

## 3.4 WORK BY OTHERS

A. The mechanical subcontractor shall install all wells, pressure tappings for flow sensors, etc., and shall set all control valves in place under the manufacturer's supervision. Pressure taps shall include service valves and calibration taps.

B. The sheet metal subcontractor shall approve or correct the submitted schedule of required control damper quantities and sizes before dampers are ordered from the factory. Sheet metal Contractor shall receive dampers at the job site, set dampers in place under the manufacturer's supervision and provide an access door for each damper. Dampers shall be mounted square within the duct without twisting or distortion to insure proper damper operation. The damper shaft shall be extended at a location that provides space for the actuator.

C. Patching and painting required for the control system installation will be accomplished by the General Contractor.

D. All line voltage wiring required for control panels, alternators, motor starters are to be furnished and installed by the electrical subcontractor.

## 3.5 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. 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. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
4. Pressure test control air piping at 30 psig or 1.5 times the operating pressure for 24 hours, with maximum 5-psig loss.
5. Test each point through its full operating range to verify that safety and operating control set points are as required.
6. Test each control loop to verify stable mode of operation and compliance with description of operation. Adjust PID actions.
7. Test each system for compliance with description of operation.
8. 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 air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. 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.

## 3.6 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.

## 3.7 DEMONSTRATION AND ACCEPTANCE.

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 017900, "Demonstration and Training."

B. The building controls system subcontractor shall submit a proposed Acceptance Test Agreement for testing the system's functionality and the accuracy of all sensors and actuators.

C. The system installation shall be complete in all respects and tested for proper operation prior to acceptance testing for the Owner's authorized representative. A letter shall be submitted to the Engineer requesting system acceptance. This letter shall certify all controls are installed and the software programs have been completely exercised for proper equipment operation. Acceptance testing will commence at a mutually agreeable time within 30 calendar days of the request. When the system has been deemed satisfactory in whole or in part by the Owner's representative, the system will be accepted for beneficial use which will start the warranty period for the commissioned portion.

## 3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230900

SECTION 230915 – VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RESPONSIBILITIES

A. Variable frequency drives (VFD) for Division 23 equipment shall be provided by the controls system subcontractor specified in Section 230900. The controls system subcontractor shall provide control wiring for VFDs.

B. Division 26 contractor shall install field mounted VFDs and provide power wiring to the VFDs and from the VFDs to their controlled motors.

C. Contract Requirements: Drawings and general provisions of the Contract, including General and Supplementary Conditions, apply to Work in this section.

1.2 QUALITY ASSURANCE

A. Regulatory Requirements: Comply with applicable city, county and state codes and ordinances.

B. Codes, Standards and References.

1. IEEE 519, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
2. NFPA 70, National Electrical Code.
3. UL 508, Industrial Control Equipment.

C. After factory assembly, test each VFD using a dynamometer to cycle from minimum to full load, including features and accessories. Include test report for each VFD in the Operation and Maintenance Manual.

D. Installer Qualifications: Installing contractor shall have successfully installed VFDs in at least 10 facilities. Installations shall be similar in configuration to this project.

E. Manufacturer shall maintain a service center or service representative within 50 miles of the project site. This center shall be capable of the following services:

1. Factory coordinated start-up service.
2. Emergency service calls, including replacement parts, within 24 hours.
3. Service agreements.
4. Training of customer personnel in operation and basic troubleshooting.

F. Provide all VFDs from a single VFD manufacturer. All VFDs shall have the same customer interface. The keypad and display shall be identical and interchangeable for all sizes of VFDs.

## 1.3 SUBMITTALS

A. Product Data. Submit manufacturer's technical product data and maintenance data for each VFD.

B. Shop Drawings. Submit control wiring diagram indicating factory and field installed wiring.

C. Total harmonic voltage distortion and total harmonic current distortion. Provide calculations, specific to this installation, showing total harmonic voltage distortion is less than 5% at the point of common coupling as described in IEEE-519. The manufacturer shall submit calculated line distortion percentages in accordance with IEEE -519, based upon the total connected horsepower and source kilovolt-amperes of the utility and emergency power distribution system. Use electrical data (transformer KvA and impedance) from the electrical drawings.

## 1.4 WARRANTY

A. Warrant VFD for 18 months 2 years from date of shipment. Warranty shall cover parts, labor, and travel time.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. Manufacturers: Danfoss, ABB, Allen Bradley. Other manufacturers will have to be preapproved and demonstrate that they meet all the requirements in this specification.

## 2.2 COMPONENTS AND REQUIREMENTS

A. Description:

1. General: Variable torque type.
2. The VFD shall convert incoming fixed frequency three-phase AC power into an adjustable frequency and voltage for controlling the speed of three-phase AC motors. The motor current shall closely approximate a sine wave. Obtain input power voltage from the mechanical equipment schedules.
3. Capable of starting, stopping, and driving an AC variable output from 0 to 60 Hz while maintaining a constant volts/hertz ratio.
4. Sized as required by motors as indicated on the Drawings. Where motor full load amps are not shown, use NEC Table 430-150 for sizing.

B. Construction:

1. UL listed and labeled assembly including specified options.
2. Separate terminal blocks for control and power wiring.

C. Enclosure: UL listed and labeled. NEMA 3R surface mounted cabinet with hinged front door, top or bottom conduit entry.

D. VFDs shall be UL listed for a short circuit current rating (SCCR) of 100kA and labeled with this rating.

E. Components and Requirements:

1. Electric disconnect lockable in OFF position with padlock.
2. Defeatable door interlock to prevent door from being opened when operating handle is in ON position.
3. Internal control power circuit with transformer and protective fuses.
4. Full load output current rating shall meet or exceed NEC Table 430-150. The VFD shall be able to provide full rated output current continuously, 110% of rated current for 60 seconds and 120% of rated torque for up to 0.5 seconds while starting.
5. The VFD shall have a dual 5% impedance DC link reactor on the positive and negative rails of the DC bus to minimize power line harmonics and protect the VFD from power line transients. The chokes shall be non-saturating. Swinging chokes that do not provide full harmonic filtering throughout the entire load range are not acceptable. VFDs with saturating (non-linear) DC link reactors shall require an additional 3% AC line reactor to provide acceptable harmonic performance at full load.
6. Limit motor noise as result of VFD to 3dB over line operation, measured at 3 feet from motor center line.
7. Adjustable acceleration and deceleration, commonly or separately, from 10 to 600 seconds.
8. Automatic adjustment of volts-to-hertz ratio to motor in proportion to load without changing speed.
9. Low frequency/low voltage starts with linear adjustable ramp up to pre-selected speed.
10. Status Indicators: Front-mounted graphical display to indicate the following conditions:

    a. Power on and run status
    b. Over voltage and over current.
    c. Line fault and external fault.

11. Front panel operator interface with keypad and alphanumeric display for parameter setting and monitoring of:

    a. Output frequency and RPM.
    b. Output voltage and output current.
    c. Faults (including memory of last 3 received faults).
    d. DC bus voltage.
    e. Calculated motor torque and calculated motor power (kW).
    f. Parameters set via keypad without removing drive cover.

12. Front panel operator interface to read in English words without use of codes.
13. Manual speed setting on local control panel.
14. Hand-off-auto keys on the keypad. In HAND position, speed is adjusted by up and down keys. In OFF position, VFD cannot be started. In AUTO position, speed is controlled by remote signal and VFD can receive remote start command. Stop command in AUTO position can be either remote, integral, or from door mounted HOA switch.
15. Fused main disconnect, lockable in open position.
16. Start into spinning motor protection. Motor may be turning in either direction.
17. Input power dip ride-through and automatic restart after power interruption and after brownout. Automatic restart selectable via software programming.
18. Critical frequency range lockout, minimum of four critical frequency ranges.
19. Output filter designed for constant duty with VFD operating at full rated load to keep rate of rise for each pulse in output below 1,000 Volts per microsecond up to 160 feet cable length.
20. Output circuitry designed for constant duty with VFD operating at full rated load to prevent peak output voltage from reaching 1,000 Volts to ground at motor up to 160 feet of cable length for VFDs up to 60HP and up to 45 feet of cable length for VFDs 75HP and larger.
21. USB and/or RS-232 Port for local communications with laptop PC for VFD setup and programming with Windows-based software.
22. Real time clock with timed action functionality.
23. Six programmable digital inputs. Two terminals shall be programmable to act as either as digital outputs or additional digital inputs.
24. Two programmable relay outputs, Form C 240VAC, 2A, for remote indication of VFD status. Each relay shall have an adjustable on delay/off delay time.
25. Two programmable analog inputs that can be either direct-or-reverse acting.

    a. Each independently selectable to be used with either an analog voltage or current signal.
    b. Each independently scalable from 0-10VDC and 4-20mA.
    c. The VFD shall provide front panel meter displays programmable to show the value of each analog input signal for system set-up and troubleshooting.

26. One programmable, scalable analog current output (4-20mA) for indication of VFD status. This output shall be programmable to show the reference or feedback signal supplied to the VFD and for VFD output frequency, current and power. It shall be possible to scale the minimum and maximum values of this output.
27. VFD and motor shall be compatible with the distance between the drive and equipment. Provide any filtering as required.

F. Optional Control and Monitoring Inputs and Outputs

1. Modules may include such items as:

    a. Additional digital outputs, including relay outputs
    b. Additional digital inputs
    c. Additional analog outputs
    d. Additional analog inputs, including Ni or Pt temperature sensor inputs

G. Serial Communications:

1. It shall be possible through serial bus communications to read the status of all analog and digital inputs of the VFD.
2. It shall be possible to command all digital and analog output through the serial communication bus.
3. The VFD shall have an RS-485 port or USB port as standard. The standard protocols included in the VFD shall be Modbus RTU, Johnson Controls N2, and Siemens FLN.
4. Optional protocols that must be available are BACnet MS/TP and LON.
5. When BACnet is specified:

    a. The VFD must be BTL listed as an Application Specific Controller (B-ASC).
    b. If the VFD does not support Change-Of-Value (COV) capabilities or Read-Property-Multiple (RPM) BACnet properties, the Controls Contractor must provide separate, dedicated MS/TP networks for VFDs.

6. Coordinate serial communication requirements with Controls Contractor.

H. Fire Alarm System Interface:

1. Include dry contact override input to stop motor under any operating condition.
2. Include dry contact override input to allow motor to operate at a speed predetermined by VFD programming.
3. Include summary alarm dry contact for connection to fire alarm system indicating that VFD is not operable.
4. Include a Fire Fighter Override Mode for "Run to destruction"

## 2.3 OPERATING CONDITIONS

A. Displacement Power Factor: Minimum 95% at any speed.

B. Efficiency: Minimum 95% at rated load and frequency.

C. AC Line Frequency Variation: ±2Hz.

D. AC Line Voltage Variation: ±10%.

E. Capacity: 100% continuous, 110% for 60 seconds.

F. Input Power: Limited to 110% of motor load.

G. Ambient Operating Temperature: 14-104ºF.

H. Relative Humidity: 0-95%, non-condensing.

I. Elevation: Up to 3,300 feet without derating output power capability.

## PART 3 - EXECUTION

### 3.1 INSPECTION AND INSTALLATION

A. General: Verify installation conditions as satisfactory to receive work of this section. Do not install until any unsatisfactory conditions are corrected. Do not install VFDs until building environment can be maintained within conditions required by manufacturer. Beginning work constitutes acceptance of conditions as satisfactory.

B. Before and during installation, protect VFD from site contaminants.

C. Coordinate required electrical and control installation work with other Divisions as required.

D. Power Wiring: Comply with requirements in Division 26.

E. Control Wiring: Comply with requirements in Section 230900.

### 3.2 START-UP SERVICES

A. Manufacturer's authorized representative shall perform the following services:

1. Verify installation connections and controls. Test continuity of each circuit.
2. Adjust safety controls.
3. Demonstrate satisfactory operation including line reactor and bypass switch during test run.
4. Program VFD to automatically reapply power and drive motor to control set point upon resumption of power following power failure.
5. Program VFD to attempt up to three automatic restarts within one hour after shutdown due to input power failure.
6. Perform field assistance and additional technical support and devices to solve problems evidenced on site related to drive operation.
7. Include field assistance and additional technical support and devices to solve problems evidenced on site related to VFD operation.
8. Include start-up reports in the Operation and Maintenance Manual.

### 3.3 TRAINING

A. Provide one two-hour training session to the owner's representative during normal business hours.

B. Training to include:

1. Demonstrate operation of operator keypads for viewing data and setting parameters.
2. Demonstrate operation in manual mode, including setting of specific speeds.
3. Explain the drive parameters that might require operator adjustment.
4. Demonstrate operation of bypass switch and door-mounted disconnect switches, if included in this project. Explain emergency operation.
5. Describe troubleshooting techniques and warranty procedure.

## 3.4 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 230915

SECTION 231123 – NATURAL GAS 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. Section Includes:

1. Pipes, tubes, and fittings.
2. Piping specialties.
3. Piping and tubing joining materials.
4. Valves.
5. Pressure regulators.
6. Mechanical sleeve seals.

1.3 DEFINITIONS

A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.

B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

1.4 PERFORMANCE REQUIREMENTS

A. Minimum Operating-Pressure Ratings:

1. Piping and Valves: 100 psig minimum unless otherwise indicated.

B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig and is reduced to secondary pressure of 0.5 psig or less.

C. Natural-Gas System Pressures within Buildings: One pressure. Pressure is less than 0.5 psig.

1.5 SUBMITTALS

A. Product Data: For each type of the following:

1. Pipes, Tubes, and Fittings
2. Piping specialties.

3. Joining Materials
4. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
5. Pressure regulators. Indicate pressure ratings and capacities.
6. Dielectric fittings.
7. Mechanical sleeve seals.
8. Escutcheons.

B. Welding certificates.

C. Field quality-control reports.

D. Operation and Maintenance Data: For pressure regulators to include in operation and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Steel Support 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.

C. 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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping when factory applied, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

B. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating and protect from direct sunlight.

PART 2 - PRODUCTS

2.1 PIPES, TUBES, AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.

1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
2. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
4. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

a. Material Group: 1.1.
b. End Connections: Threaded or butt welding to match pipe.
c. Lapped Face: Not permitted underground.
d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum O-rings, and spiral-wound metal gaskets.
e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless- s t e e l underground.

## 2.2 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
3. Operating-Pressure Rating: 0.5 psig.
4. End Fittings: Zinc-coated steel.
5. Threaded Ends: Comply with ASME B1.20.1.
6. Maximum Length: 72 inches.

B. Quick-Disconnect Devices: Comply with ANSI Z21.41.

1. Copper-alloy convenience outlet and matching plug connector.
2. Nitrile seals.
3. Hand operated with automatic shutoff when disconnected.
4. For indoor or outdoor applications.
5. Adjustable, retractable restraining cable.

C. 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.

D. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

## 2.3 JOINING MATERIALS

A. Joint Compound and Tape: Suitable for natural gas.

B. 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.

C. Brazing Filler Metals: Alloy with melting point greater than 1000 deg F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

## 2.4 MANUAL GAS SHUTOFF VALVES

A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.

1. CWP Rating: 125 psig.
2. Threaded Ends: Comply with ASME B1.20.1.
3. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
4. Tamperproof Feature: Locking feature for valves indicated in "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.

B. General Requirements for Metallic Valves, NPS 2-1/2 and Larger: Comply with ASME B16.38.

1. CWP Rating: 125 psig.
2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
4. Service Mark: Initials "WOG" shall be permanently marked on valve body.

C. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.

1. Manufacturers:

   a. BrassCraft Manufacturing Company; a Masco company.
   b. Conbraco Industries, Inc.; Apollo Div.
   c. Lyall, R. W. & Company, Inc.
   d. McDonald, A. Y. Mfg. Co.
   e. Perfection Corporation; a subsidiary of American Meter Company.

2. Body: Bronze, complying with ASTM B 584.
3. Ball: Chrome-plated bronze.
4. Stem: Bronze; blowout proof.
5. Seats: Reinforced TFE; blowout proof.
6. Packing: Threaded-body packnut design with adjustable-stem packing.

7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
8. CWP Rating: 600 psig.
9. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
10. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

D. Bronze Plug Valves: MSS SP-78.

1. Manufacturers:

a. Lee Brass Company.
b. McDonald, A. Y. Mfg. Co.

2. Body: Bronze, complying with ASTM B 584.
3. Plug: Bronze.
4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
5. Operator: Square head or lug type with tamperproof feature where indicated.
6. Pressure Class: 125 psig.
7. Listing: Valves NPS 1 and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
8. Service: Suitable for natural-gas service with "WOG" indicated on valve body.

## 2.5 PRESSURE REGULATORS

A. General Requirements:

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

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

a. American Meter Company.
b. Eclipse Combustion, Inc.
c. Fisher Control Valves and Regulators; Division of Emerson Process Management.
d. Invensys.
e. Maxitrol Company.
f. Richards Industries; Jordan Valve Div.

2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.

5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

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

   a. Canadian Meter Company Inc.
   b. Eaton Corporation; Controls Div.
   c. Harper Wyman Co.
   d. Maxitrol Company.
   e. SCP, Inc.

2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc-plated steel; interchangeable.
4. Diaphragm Plate: Zinc-plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
7. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 2 psig.

## 2.6 DIELECTRIC FITTINGS

A. Dielectric Unions:

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

   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Hart Industries International, Inc.
   d. McDonald, A. Y. Mfg. Co.
   e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   f. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.

4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges:

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

   a. Capitol Manufacturing Company.
   b. Central Plastics Company.
   c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
   d. Wilkins; Zurn Plumbing Products Group.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, plain, or welded end connections that match piping system materials.

C. Dielectric-Flange Kits:

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

   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Central Plastics Company.
   d. Pipeline Seal and Insulator, Inc.

2. Minimum Operating-Pressure Rating: 150 psig.
3. Companion-flange assembly for field assembly.
4. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, plain, or welded end connections that match piping system materials.

## 2.7 SLEEVES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast- Iron Pipe Sleeves: Cast or fabricated “wall pipe”, equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

## 2.8 MECHANICAL SLEEVE

A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.

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

   a. Advance Products & Systems, Inc.
   b. Calpico Inc.
   c. Metraflex Company (The).
   d. Pipeline Seal and Insulator, Inc.

2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
3. Pressure Plates: Stainless steel.
4. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine roughing-in for natural-gas piping system to verify actual locations of piping connections before equipment installation.

## 3.2 PREPARATION

A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

B. Inspect natural-gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural-gas utilization devices are turned off in piping section affected.

C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

## 3.3 OUTDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Install fittings for changes in direction and branch connections.

C. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve seals.

1. Install steel pipe for sleeves smaller than 6 inches in diameter.

2. Install cast-iron “wall pipes” for sleeves 6 inches and larger in diameter.

D. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

E. Install pressure gage downstream from each service regulator.

## 3.4 INDOOR PIPING INSTALLATION

A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural-gas piping.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.

D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

E. 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.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Locate valves for easy access.

H. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install escutcheons at penetrations of interior walls, ceilings, and floors.

1. New Piping:

a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.
c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped- steel type.
d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast-brass type with polished chrome-plated finish.

e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
f. Piping in Unfinished Service Spaces: One-piece, cast-brass type with rough-brass finish.
g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with concealed or exposed-rivet hinge and set screw or spring clips.
h. Piping in Equipment Rooms: One-piece, cast-brass type.
i. Piping in Equipment Rooms: One-piece, stamped-steel type with set screw or spring clips.
j. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.

L. Verify final equipment locations for roughing-in.

M. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.

N. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.

1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.

O. Extend relief vent connections for line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.

P. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.

Q. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.

1. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
2. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.

a. Exception: Tubing passing through partitions or walls does not require striker barriers.

3. Prohibited Locations:

a. Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
b. Do not install natural-gas piping in solid walls or partitions.

R. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.

S. Connect branch piping from top or side of horizontal piping.

T. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.

U. Do not use natural-gas piping as grounding electrode.

V. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.

W. Install pressure gage downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

## 3.5 VALVE INSTALLATION

A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing connector.

B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

## 3.6 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.

## 3.7 HANGER AND SUPPORT INSTALLATION

A. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 1 and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
2. NPS 1-1/4: Maximum span, 108 inches; minimum rod size, 3/8 inch.
3. NPS 1-1/2 and NPS 2: Maximum span, 108 inches; minimum rod size, 3/8 inch.
4. NPS 2-1/2 to NPS 3-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.

B. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:

1. NPS 3/8: Maximum span, 48 inches; minimum rod size, 3/8 inch.
2. NPS 1/2: Maximum span, 72 inches; minimum rod size, 3/8 inch.
3. NPS 3/4 and Larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

## 3.8 CONNECTIONS

A. Connect to utility's gas main according to utility's procedures and requirements.

B. Install natural-gas piping electrically continuous and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.

C. Install piping adjacent to appliances to allow service and maintenance of appliances.

D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install a union between the valve and appliances or equipment.

E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

## 3.9 LABELING AND IDENTIFYING

A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

## 3.10 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.

C. Natural-gas piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

## 3.11 OUTDOOR PIPING SCHEDULE

A. Aboveground natural-gas piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

## 3.12 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with wrought-steel fittings and welded joints.

## 3.13 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES MORE THAN 0.5 PSIG AND LESS THAN 2 PSIG

A. Aboveground, branch piping NPS 1 and smaller shall be the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2.

B. Aboveground, distribution piping shall be one of the following:

1. Steel pipe with malleable-iron fittings and threaded joints.
2. Steel pipe with steel welding fittings and welded joints.

## 3.14 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

A. Distribution piping valves for pipe sizes NPS 2 and smaller shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

B. Distribution piping valves for pipe sizes NPS 2-1/2 and larger shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

C. Valves in branch piping for single appliance shall be one of the following:

1. Two-piece, full-port, bronze ball valves with bronze trim.
2. Bronze plug valve.

END OF SECTION 231123

SECTION 232100 - 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.

B. Related Sections include the following: Division 23, Section 232123, "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.3 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:

1. Chilled-Water Piping: 150 psig at 200°F.
2. Air-Vent Piping: 150 psig at 200°F.

1.4 SUBMITTALS

A. Product Data: Submit for each type of the following: Plastic pipe and fittings with solvent cement.

B. Submit product data for metal pipe and tubing, with specification, class or type, and schedule.

1. Valves. Include material data, pressure/temperature ratings, 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.

C. Shop Drawings: Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

D. Welding certificates.

E. Field quality-control test reports.

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

## 1.5 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.
3. Systems operating above 150 psi must comply with ASME B31.1 or B31.3

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.

D. Coordinate inspection work with owner designated welding inspector.

E. Piping shall have identification affixed at factory with proper ASTM identification. Piping specialties, including valves, shall have the manufacturer's trademark, name and/or model number and pressure rating, where applicable, affixed to permanently identify the manufacturer of product.

# PART 2 - PRODUCTS

## 2.1 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type K or L.

B. Wrought-Copper Fittings: ASME B16.22.

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:
2. Basis-of-Design Product: Subject to compliance with requirements, provide:

a. Anvil International, Inc.
b. S. P. Fittings; a division of Star Pipe Products.
c. Victaulic Company of America.
d. Stadler-Viega

e. Bronze Flanges and Flanged Fittings: ANSI/ASME B16.24.

3. Copper or Bronze Pressure-Seal Fittings:

a. Manufacturer: Subject to compliance with requirements, provide products manufactured by Stadler-Viega.
b. Housing: Copper.
c. O-Rings and Pipe Stops: EPDM.
d. Tools: Manufacturer's special tools.
e. Minimum 200-psig (1379-kPa) working-pressure rating at 250 degrees F (121 degree C.)

C. Wrought-Copper Unions: ASME B16.22.

## 2.2 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.

a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.

2. Submit gasket compatability data for glycol service.

B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated. Carbon steel machine bolts or studs and nuts, ASTM A307, Grade B.

C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.

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

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

F. 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.

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

## 2.3 DIELECTRIC FITTINGS

A. Description: Combination fitting of copper-alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

B. Dielectric Fittings Two-inch and Smaller: Threaded dielectric union, ANSI/ASME B16.39.

C. Dielectric Fittings 2-1/2-inch and Larger: Flanged union with dielectric gasket and bolt sleeves, ANSI/ASME B16.42.

D. Insulating Material: Suitable for system fluid, pressure, and temperature.

E. Dielectric Unions:

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. Capitol Manufacturing Company
   b. Central Plastics Company
   c. Hart Industries International, Inc.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Zurn Plumbing Products Group; AquaSpec Commercial Products Division

2. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 degrees F.

## 2.4 VALVES

A. General Requirements For Valves:

1. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
2. Valve Sizes: Same as upstream piping unless otherwise indicated.
3. Valve Actuator Types:

   a. Gear Actuator: For quarter-turn valves NPS 6 and larger.
   b. Handwheel: For valves other than quarter-turn types.
   c. Handlever: For quarter-turn valves NPS 4 and smaller.
   d. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article.

4. Valves in Insulated Piping: With two-inch stem extensions and the following features:

   a. Gate Valves: With rising stem.
   b. Ball Valves: With extended operating handle of nonthermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
   c. Butterfly Valves: With extended neck.

5. Valve-End Connections:

   a. Flanged: With flanges according to ASME B16.1 for iron valves.
   b. Grooved: With grooves according to AWWA C606.

c. Threaded: With threads according to ASME B1.20.1.
d. Valve Bypass and Drain Connections: MSS SP-45.

B. HVAC Water System Valves (Not Grooved-End)

1. General: Utilize the following valves for water-based systems, such as chilled water, condenser water and heating water.
2. Shut-Off Valves 2" and Smaller: Ball type, ASTM B-61, ASTM B-62. Bronze body shall be ASTM B584 Alloy C84400. Two-piece body style, threaded ends, full port, chrome plated bronze ball, Teflon seats, adjustable packing, lever handle, blowout proof stem, 150 wsp, 600 wog.

   a. Manufacturer:

      1) Apollo No. 77C
      2) Crane 9303-B
      3) Milwaukee BA-400
      4) Nibco No. T-585-70
      5) Watts No. B-6080
      6) Red-White No. 5044F

3. Shut-Off Valves 2" and Smaller: Ball type, ASTM B-61, ASTM B-62. Bronze body shall be ASTM B584 Alloy C84400. Two-piece body style, threaded ends, full port, ASTM 276 Type 316 stainless steel ball and stem, Teflon seats, adjustable packing, lever handle, blowout proof stem, 150 wsp, 600 wog.

   a. Manufacturer:

      1) Apollo No. 77C-140
      2) Crane 9303-S
      3) Nibco No. T-585-70-66

4. Shutoff Valves 2-1/2" through 12”: Butterfly type, full lug, ductile iron body, 400 series stainless steel stem, aluminum bronze disc, EPDM liner and seals, upper and lower stem bearing, blowout proof stem, extended neck for minimum 2" insulation, manufacturer recommended for bi-directional dead end service at full rated pressure without a downstream flange, sizes 2-1/2" through 4" shall be lever operated and 200 psi cwp; 6" through 12" shall be gear operated and 200 psi cwp; 14" and larger shall be gear operated and 150 psi cwp.

   a. Manufacturer:

      1) Demco No. NEC-511
      2) Keystone No. HS-2
      3) Milwaukee No. CL Series
      4) NIBCO No. LD-2000

5. Gate Valves 2" and Smaller: Bronze body, solid wedge disc, nonrising stem, screw-in bonnet, malleable iron hand wheel, threaded ends, 125 wsp, 200 wog.

   a. Manufacturer: Milwaukee No. 105, NIBCO No. T-113, Stockham No. B-103.

6. Swing Check Valves 2" and Smaller: Bronze body, swing check, Teflon disc and seat, 125 wsp, 200 wog.

   a. Manufacturer:

      1) Hammond IB940
      2) Milwaukee No. 509-T
      3) NIBCO No. T-413-Y
      4) Red-White No. 236T
      5) Stockham No. B-320-T

7. Swing Check Valves 2-1/2" and Larger: Cast-iron body, horizontal swing check, bronze trim, with brass-faced disc, brass body seat ring, flanged pattern, 125 wsp, 200 wog.

   a. Manufacturer:

      1) Crane 373
      2) Hammond IR1124
      3) Milwaukee No. F2974-A
      4) NIBCO No. F-918-B
      5) Red-White No. 435
      6) Stockham No. G-93

8. Pump Check Valves, Non-slam Type 2-1/2" and Larger: Wafer style, cast-iron body, bronze disc and seat, center guided, stainless steel spring and screws, 200 nonshock wog.

   a. Manufacturer:

      1) Hammond IR9253
      2) Metraflex Style 700
      3) Milwaukee No. 1400
      4) NIBCO No. W-910-B

C. Grooved-End HVAC Water System Valves:

1. General: At Contractor's option, the following valves may also be used for 2-1/2" and larger water-based systems, such as chilled water, condenser water and heating water.
2. Ball Valves 2-1/2" to 3" Sizes: Ductile iron, two-piece body, grooved ends, standard port, chrome plated carbon steel ball and stem, TFE seats, lever handle, blow out proof stem, 740 psi cwp.

   a. Manufacturer:

      1) Anvil Gruvlok Series 7500
      2) Nibco No. G-595-Y/G-590-Y
      3) Victaulic Series 726

3. Butterfly Valves 2-1/2" to 4": Ductile iron body, EPDM synthetic rubber encapsulated ductile iron disc with integrally cast stem, lever operated with 10-position throttling plate, manufacturer recommended for bi-directional dead end service at full rated pressure without a downstream flange, 300 psi cwp.

a. Manufacturer:

1) Anvil Gruvlok Series 7700
2) Nibco No. GD-4765-3
3) Victaulic Vic®-300

4. Check Valves 2-1/2" and Larger: Ductile iron body, horizontal or vertical spring-assisted check, stainless steel spring and shaft, grooved pattern, 300 psi cwp.

a. Manufacturer:

1) Anvil Gruvlok Series 7800
2) Victaulic Series 716

5. Pump Check Valves 2-1/2" and Larger: Ductile iron body, horizontal or vertical spring-assisted check, stainless steel spring and shaft, grooved pattern 300 psi cwp.

a. Manufacturer:

1) Anvil Gruvlok Series 7800
2) Victaulic Series 716

## 2.5 SPECIALTY VALVES AND ACCESSORIES

A. Combination Balancing/Shut-Off Valves:

1. Provide balancing valves at coils, at circulating pumps and elsewhere as shown.
2. Manufacturer: Nibco 1710, Armstrong "CBV" Circuit Balancing Valves, Bell & Gossett "Circuit Setter Plus" or Tour-Anderson Model STAD/STAS and STAF/STAG.
3. Meter: Balancing valve manufacturer shall provide one portable meter for reading differential pressure in feet head. Each meter connection shall have positive shutoff valves. Meter shall have liquid-filled pressure gauge.
4. Valves shall be globe body, flanged pattern and all metal parts of nonferrous, pressure die-cast, flow measurement; shall provide four functions:

a. Precise flow measurement
b. Precision flow balancing
c. Positive shut-off with no-drip seat and Teflon disc
d. Drain connection with protective cap.

5. Valves shall have four 360-degree adjustment turns of handwheel for maximum Vernier-type setting with "Hidden Memory" feature to program the valve with precision tamperproof balancing setting.

B. Balance Valves (Larger pipe sizes, balancing only):

1. Valves shall be globe body, flanged pattern and all metal parts of nonferrous, pressure die-cast, nonporous copper alloy. Valves shall be capable of installation in any direction without affecting flow measurement; shall provide four functions:

a. Precise flow measurement.

b. Precision flow balancing.
c. Positive shut-off with no-drip seat and Teflon disc, and
d. Drain connection with protective cap.

2. Valves shall have four 360°-adjustment turns of handwheel for maximum Vernier-Type setting with "Hidden Memory" feature to program the valve with precision tamperproof balancing setting.
3. Provide hand-wheel protective cover to prevent accumulation of dirt and over-painting during construction.
4. Manufacturer: Armstrong "CBV" Circuit Balancing Valves, Tour-Andersson Model STAD/STAS and STAF/STAG or Mepco MBVS.

C. Flow Measuring Device:

1. Low loss venturi type, IMI AccuSetter VW, VG, or VF, with P/T ports and metal tag.

D. Drain Valves 1/2" to 3/4" Sizes: Bronze ball valve, two-piece body, standard port, chrome plated brass ball, RPTFE seats, lever handle, blow out proof stem, threaded or soldered with hose end, cap and chain, 150 psi wsp, 600 psi wog. Manufacturer: Milwaukee No. BA-100H or BA-150H.

E. Bronze, Calibrated-Orifice, Balancing Valves:

1. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of 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 degrees F.

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

1. Basis-of-Design Product: Subject to compliance with requirements, provide:

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 of America

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 degrees F.

## 2.6 AIR CONTROL DEVICES

A. Manual Air Vents: Compression-type, screwdriver-operated air cocks shall be furnished and installed where shown and where required for venting. Cocks shall be 1/4" in size and shall be all bronze construction.

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/8.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 degrees F.
8. Manual Air Vents 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; a division of ITT Industries
d. Taco

B. Automatic Air Vents (High Pressure): Single lever float type, 250 psi, 300°F cast iron body, 1/2" or 3/4" pipe connection as indicated. Float and internal mechanisms shall be stainless steel. Manufacturer: Hoffman No. 792, Armstrong No. 21 or approved Taco.

C. Automatic Air Vents (Low-Pressure): Built-in serviceable check valve, all construction either brass or stainless steel.

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

    a. Hoffman No. 79 Low Pressure
    b. Approved Taco, Amtrol, Bell & Gossett

D. Bladder-Type Expansion Tanks:

1. Construction: Welded steel, designed, tested and stamped in accordance with ASME (BPV code sec VIII, div 1); supplied with National Board Form U-1, rated for working pressure of 125 psi, with flexible seamless heavy duty butyl rubber bladder. (optional 150 psi ) Bladder shall be able to accept the partial volume of the expansion tank and shall be removable and replaceable. The bladder shall be fabricated with special fluting that allows the bag to more easily collapse and facilitate replacement. The bladder shall be supported with a pole on units larger than 22 gallons. The support pole shall be connected at both the top and bottom and shall have distribution holes that facilitate even expansion of the bladder.
2. System connection will be via a ¾ inch NPT connection on the bottom of the tank. A Schrader valve fitting shall be installed at the top of the tank to allow external pressurization of the bladder. Valve shall be protected by a 1½ "coupling welded to the tank.
3. Accessories: Pressure gage (field installed in adjacent piping by others) and air-charging fitting.
4. Automatic Cold Water Fill Assembly (field installed by others): Pressure reducing valve, reduced pressure double check back flow preventer, test cocks, strainer, vacuum breaker, and valved bypass.
5. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

    a. Armstrong
    b. Taco

2.7 AIR SEPARATORS:

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

1. Spirotherm – Spirovent
2. Caleffi
3. Flamco
4. Taco

B. Air and dirt removal device shall be constructed of steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 psi at 240°F. Manufacturer shall be holder of ASME U stamp. Manufacturer to have optional 150, 250 and 300psi ASME units available.

C. Units up to three 3-inch in size shall be provided with threaded connections as standard. Units four 4-inch and larger shall be provided with flanged system connections as standard. Inlet and outlet connections to be inline with piping system. Both inlet and outlet to be in the same horizontal and vertical planes.

D. Each air and dirt removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill.

E. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator.

F. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning. On units 2 ½" and smaller the valve and all of its fittings shall be 1". On units three 3" and larger the valve and all openings shall be 2".

G. The air and dirt removal device shall remove air down to 18 microns and shall remove dirt/debris down to 5 microns. The unit shall be 100% efficient at removing dirt down to 150 microns in 10 passes or less at 3.5ft/sec.

H. The unit manufacturer shall provide the owner and design engineer third party independent test data certifying that their unit performs to the above standards. Suppliers not providing these independent performance test results will not be acceptable.

I. The air and dirt separator shall employ the use of high surface area pall rings to achieve optimal separation of air and dirt with minimal pressure drop. The pall rings shall be made of stainless steel. Stainless steel will be the only acceptable material used for suppressing turbulence and increasing surface area for high efficiency air and dirt removal. Inferior materials of construction such as copper for the straining medium will not be acceptable.

J. The unit shall be manufactured with a switchable on/off style Neodymium magnet assembly which does not require removal from vessel to facilitate maintenance and cleaning.

## 2.8 PRESSURE AND TEMPERATURE TEST STATIONS

A. Test Plugs: Provide 1/2" size, pressure and temperature type fitting constructed of solid brass with two valve cores of Nordel, suitable for 275°F at 500 psi. Each fitting shall include cap with gasket. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Peterson Equipment Co., "Pete's Plugs" or approved Sisco.
2. Test Plugs in Insulated Piping: Pete's Plug "XL" Series or approved Sisco or Flow Design.

B. Test Kit: Provide test kit consisting of 0–100 psi, 0–230 feet of water pressure gauge with gauge adapter attached, a 25–125°F pocket testing thermometer, a 0–220°F pocket testing thermometer and gauge adapter.

## 2.9 CHEMICAL TREATMENT

A. Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in systems indicated to contain antifreeze or glycol solutions. Contractor shall provide all propylene glycol refilling as required during one-year guarantee period. Provide four sample kits and testing for quarterly evaluation of the glycol solution. Testing to be done by the glycol manufacturer or certified lab capable of evaluating glycol samples for proper mix and corrosion inhibitor concentration. Charge the following systems to the glycol concentrations by weight indicated on drawings.

1. Provide all necessary inhibitors or other additives required and recommended by the glycol manufacturer for use with ferrous and nonferrous metals.
2. Provide glycol manufacturer's premixed glycol/water solution, in the required concentration. Water in premix solution shall be distilled or demineralized water.
3. Test equipment for glycol shall be furnished and approved by the glycol manufacturer.
4. Manufacturer: Dow, Dowfrost or approved equal.

B. Glycol System Make-Up Package:

1. Provide a factory-packaged system for automatic make-up for the glycol system. Tank and pump assembly must be suitable for installation with minimum of four legs and feet drilled for bolting to floor.
2. The packaged unit shall be designed to operate on standard 110VAC, 60 Hz electrical circuits and shall maintain a fill pressure of 10 to 50 psig.
3. Unit shall include cut-off and alarm arrangement that will stop the pump in case of excessive pressure, or a low solution level, and activate an alarm contact. A 110 VAC signal shall be provided for a remote alarm.
4. A translucent polyethylene solution container, complete with lid, shall be mounted on the pumping assembly and shall include a strainer and a shut off valve. Glycol solution recovery lines shall be piped in from the system relief valves and other points as indicated to the solution container, through its lid in such a way that the lid can be removed for filling and mixing.
5. The pumping assembly shall be mounted in a sturdy steel frame with legs to keep it off the floor. It shall include a 1.8 gpm at 50 psi pump, a 1/3 HP motor, a magnetic starter, a pressure tank with a pressure control, a priming valve, a PRV, a shut-off valve, and a pressure gauge. The pumping assembly shall be connected to the system with a ½" NPT connection.
6. Manufacturers: Wessels Company, Axiom.

## 2.10 HYDRONIC PIPING SPECIALTIES

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

1. Mueller Steam Company
2. Armstrong Pump
3. Watts
4. Metraflex
5. Armstrong International, Inc.
6. Hoffman Specialty; Division of ITT Industries

7. Spence Engineering Company, Inc.
8. Spirax Sarco, Inc.
9. Bell & Gossett
10. Taco

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection for flanged end units.
2. End Connections: Threaded ends for NPS 2 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger; soldered ends above suspended ceilings NPS 2 and smaller.
3. Start-up Strainer Screen: 40-mesh startup strainer,
4. Operational Strainer Screens: 20 mesh stainless steel strainer 2” and smaller; 1/16” perforated monel or stainless-steel basket with 50 percent free area for 2-1/2" to 5"; 1/16” perforated monel or stainless-steel basket with 50 percent free area 6" and larger.
5. CWP Rating: 250 psig 2” and Smaller, 200 psig soldered end bodies, 125 psig 2-1/2” and larger.

C. Flexible connectors are specified in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC."

D. Expansion fittings are specified in Division 23, Section 230500, "Common Work Results for HVAC."

## PART 3 - EXECUTION

### 3.1 PIPING APPLICATIONS

A. Chilled-water piping, aboveground, NPS 2 (DN 50) and smaller, shall be the following:

1. Type L drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.

B. Chilled-water piping, aboveground, NPS 2-1/2 (DN 65) and larger, shall be the following:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered or brazed joints.

C. Condensate-Drain Piping: Type M drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

D. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

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 (A), annealed-temper copper tubing with soldered or flared joints.

F. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.

## 3.2 VALVE APPLICATIONS

A. Install ball or butterfly type 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 check valves at each pump discharge and elsewhere as required to control flow direction.

## 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. The drawings do not show all required fittings and offsets that may be necessary to connect pipes to equipment and to coordinate with other trades. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected.

B. Install components furnished under other sections, such as: Control valve bodies, flow switches, pressure taps with valve, and wells for sensors.

C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls and column lines. Diagonal runs are prohibited unless specifically indicated otherwise.

E. Space piping, including insulation, to provide one-inch minimum clearance between adjacent piping and other surfaces.

F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

G. Install piping to permit valve servicing.

H. Install piping at indicated slopes.

I. Install piping free of sags and bends.

J. Install fittings for changes in direction and branch connections.

K. Install piping to allow application of insulation.

L. Select system components with pressure rating equal to or greater than system operating pressure.

M. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

N. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded hose adapter with cap, at low points in piping system mains and elsewhere as required for system drainage. Drains are generally not shown on the drawings.

1. Where piping is located in heated space, provide drain valves at all low points where more than three gallons of water could be trapped.
2. Where piping is located in unheated space, including insulated piping with heat tracing, provide drain valves at all low points where any water could be trapped. In general, piping should be arranged to minimize the need for drain valves.
3. Where drain valves are indicated on the drawings, extend piping as noted.

O. Provide manual air vents at all high points in the piping systems where air might accumulate. Manual air vents are generally not shown on the drawings. Air vent valves shall be located in an accessible location and shall be positioned with discharge down such that a container can be held under the valve to receive liquid discharge. Provide tubing (same size as vent valve) from the top of the pipe to be vented to the accessible vent valve.

P. Provide automatic air vents where indicated on the drawings. Discharge from automatic air vents shall be field-piped to the nearest floor drain with a one inch air gap.

Q. Glycol systems: In glycol systems, pipe drain and vent valves back to glycol mix tank, or glycol catch tank, do not discharge glycol to floors, floor drains or to outside.

R. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

S. Locate and orient valves to permit proper operation and access for maintenance. Generally locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing. Install butterfly valves with the valve open as recommended by the manufacturer to prevent binding of the disc in the seat.

T. Install unions or flanges in piping adjacent to valves, at final connections of equipment, and elsewhere as indicated. Offset equipment connections and carefully locate unions and flanges to allow for equipment removal and repair with minimal removal of piping. Provide flexibility in equipment connections and branch line take-offs with three-elbow swing joints or as noted on the drawings.

U. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Strainers shall be installed line size, which shall mean the size of the inlet pipe shown on the drawings, not the reduced size serving the valve or equipment. 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.

V. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23, Section 230500, “Common Work Results for HVAC."

W. Identify piping as specified in Division 23, Section 230550, "Identification for Piping and Equipment."

X. Test plugs in insulated piping shall have stem length as determined by insulation thickness.

Y. Tee water piping runouts or branches into the side of mains or other branches. Where possible, do not use bull-head tees, which are two lines flowing into opposite ends of a tee and exiting out the common side.

Z. Dielectric fittings shall be used at piping connections between copper and dissimilar metals at equipment or piping to protect from galvanic corrosion. Where dissimilar piping materials are separated by dielectric fittings the separation shall include isolation of pipe hangers by insulation, plastic coated hangers or support from a nonconductive structure.

## 3.4 HANGERS AND SUPPORTS

A. Install the following pipe attachments:

1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Spring hangers to support vertical runs.
5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.

B. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, seven feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, seven feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, nine 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, 14 feet; minimum rod size, 1/2 inch.

C. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, five feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, six feet; minimum rod size, 1/4 inch.
3. NPS 1-1/2: Maximum span, eight feet; minimum rod size, 3/8 inch.
4. NPS 2: Maximum span, eight feet; minimum rod size, 3/8 inch.
5. NPS 2-1/2: Maximum span, nine feet; minimum rod size, 3/8 inch.
6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.

D. 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
3. Make up joint so only three threads show.

G. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads. Tighten flange bolts in accordance with gasket manufacturer’s recommendations. Use full face gaskets and flat face flanges when connecting to equipment or valves with cast iron flat face flanges.

I. Pressure-Sealed Joint: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

J. 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.

K. Flexible Connectors: The piping gap shall be equal to the length of the expansion joint under pressure. Control rods passing through 1/2” thick Neoprene washer bushings large enough to take the thrust at 1000 psi of surface area may be used on unanchored piping where the manufacturer determines the condition exceeds the expansion joint rating without them. All flexible connectors shall be installed on the equipment side of the shut off valves.

## 3.6 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. Manual vents at heat-transfer coils and elsewhere as required for air venting.

C. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.

D. 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.

## 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 bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections.

## 3.8 SYSTEM CLEANING

A. 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.

B. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

C. Fill systems indicated to have antifreeze or glycol solutions with the concentrations indicated on drawings.

D. Preparation of Piping Systems:

1. System shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system. Record capacity and include in Operation and Maintenance manuals.
2. Make temporary piping connections; furnish temporary pumps, and temporary bypass filter as required to properly accomplish all cleaning operations.
3. Place all manual and control valves serving coil banks and terminal control units in open position during cleaning so that circulation through the mains and runouts is obtained during cleaning.

E. Piping System Cleaning Sequence: The services of a chemical treatment specialist shall be used for procedure and chemical selection.

1. Qualified Contractors: Ashland Specialty Chemical, Garratt Callahan and the Nalco Company.

    a. Company shall only utilize qualified personnel active in the field of water treatment who are factory trained or authorized.
    b. A single water treatment company for undivided responsibility shall perform startup, system check, water samples, analysis, cleaning, flushing, and testing.

2. Initial Flush, All Systems:

    a. Completely fill the system with fresh water and circulate (1st filling).
    b. Initial flushing shall be sufficient to remove all contaminants such as cuttings, filings, loose rust & scale, welding and soldering residue and debris.
    c. Drain the entire system, including dead legs, and refill with fresh water (2nd filling).

3. Closed Systems:

    a. Add the recommended dosage of cleaning solution to the system, circulate and bring up to the recommended temperature.
    b. Test solution for proper concentration and document results.
    c. Circulate the solution for the time recommended by the manufacturer (4 hours minimum and not to exceed the manufacturer's maximum limit).
    d. Partially close and reopen all manual valves several times.
    e. Operate all automatic valves through several cycles.
    f. Completely drain the entire system.
    g. Fresh Water Flush: Refill the system with fresh water (3rd filling). Then, with circulation pump running:

        1) Open one or more drains as far downstream from the fill point as is possible. Be sure the makeup is sufficient to keep up with the drain so as to maintain a full system.
        2) Partially close and reopen all manual valves several times.
        3) Blowdown all strainer, dead legs and low points in the system.
        4) Operate all automatic valves through several cycles.
        5) Continue to flush the system in this manner until the drain water is of the same clarity as the makeup water and testing reveals no further traces of cleaning solution (minimum one hour). Document the results.

    h. Following the fresh water flush, drain the entire system:

        1) Clean all strainers.
        2) Remove all startup strainers.
        3) Drain all dead legs.

    i. Fill System (Glycol Systems):

        1) Fill system with specified glycol, water and chemicals.

2) Glycol solution MUST BE ADDED WITHIN TWO HOURS after final draining of the system.
3) The cleaning firm shall, upon completion of filling system with glycol solution, tag each system so that tag is plainly visible as follows: “CAUTION THIS SYSTEM HAS BEEN “CHARGED” WITH GLYCOL. DO NOT DILUTE SYSTEM WITH WATER OR DRAIN SYSTEM WITHOUT AUTHORIZATION.”

## 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. Provide temporary valving or cap piping at connections to existing systems as required to confine testing to the new piping systems.
5. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
6. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks. System must be proven to hold pressure for two hours.
7. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.

4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

## 3.10 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 232100

SECTION 232123 - HYDRONIC PUMPS

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. Close-coupled, in-line centrifugal pumps.

1.3 DEFINITIONS

A. Buna-N: Nitrile rubber.

B. EPT: Ethylene propylene terpolymer.

1.4 SUBMITTALS

A. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

B. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.

1. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

D. Submittals shall be approved prior to shipping from factory.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.

B. Product Options: Drawings indicate size, profiles, and dimensional requirements of hydronic pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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

D. UL Compliance: Comply with UL 778 for motor-operated water pumps.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

## 1.7 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.

## 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. Mechanical Seals: One mechanical seal(s) for each pump.

# 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 GENERAL

A. Motors shall be matched to pump for non-overloading service at the design impeller diameter and full speed in variable speed applications.

B. Motor size shall be as scheduled.

## 2.3 CLOSE-COUPLED, VERTICAL, IN-LINE CENTRIFUGAL PUMPS

A. Basis-of-Design Product: Taco KV Series

B. Manufacturers:

1. Taco
2. Armstrong Pumps Inc.
3. Aurora Pump; Division of Pentair Pump Group.
4. Bell & Gossett.
5. Burks Pumps; Div. of Crane Pumps & Systems.
6. Grundfos Pumps Corporation.
7. Patterson Pump Co.

C. Source Limitations: Obtain pumps from single source from single manufacturer.

D. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 14.1, HI 14.2 and HI 14.3; designed for installation with pump and motor shafts mounted horizontally or vertically.

E. Pump Construction:

1. Casing: Radially split, cast iron, with threaded gauge tappings at inlet and outlet, replaceable bronze wear rings, and threaded companion-flange connections.
2. Impeller: Type 304 stainless steel; statically and dynamically balanced, keyed to shaft, and secured with a stainless steel locking cap screw. For pumps that are not variable-frequency-drive controlled, trim impeller to match specified performance.
3. Pump Shaft Sleeve: Type 304 stainless steel.
4. Pump Stub Shaft: Type 304 stainless steel.
5. Seal: Mechanical seal consisting of ceramic/EPT, and NBR rubber bellows and gasket. Include water slinger on shaft between motor and seal.
6. Seal Flushing: Flush, cool, and lubricate pump seal by directing pump discharge water to flow over the seal.

F. Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."

1. Enclosure: Totally enclosed, fan cooled.
2. NEMA Premium 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 electrical Sections.
5. Single or Variable-frequency motor depending on application.

## 2.4 PUMP SPECIALTY FITTINGS

A. Manufacturer shall be same as pump provided:

B. Suction Diffuser: Angle pattern, with end cap, pump-inlet fitting; with bronze startup strainer and bronze or stainless-steel permanent orifice cylinder with 5/32" or 3/16" diameter openings; bronze or stainless-steel straightening vanes; and drain plug. Orifice cylinder shall have a 2:1 free area of pump suction openings. Total vane length shall be no less than 2-1/2 times the pump connection diameter. Pressure and temperature rating shall be same as pump. Unit shall be provided with base support boss to carry weight of suction piping.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.

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

## 3.2 PUMP INSTALLATION

A. Comply with applicable standard HI 1.4 or HI 2.4.

B. Install pumps with access for periodic maintenance including removal of motors, impellers, couplings, and accessories.

C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.

D. Vibration isolation devices are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required. Hanger and support materials are specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

E. Vibration-isolated Pumps: Bases are specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Contractor shall furnish pump manufacturer's template for setting pump to inertia base manufacturer prior to submittal phase of project. Install with flexible connectors.

F. Non-isolated Pumps: Mount pump and motor on heavy structural steel baseplate having a sufficient grout volume with adequately sized grout holes. Grout entire base with nonshrinking grout. Align pump and driver after grouting is completed. After alignment, all bolts holding the pump end and motor to the base will be tightened to the manufacturer specified torque value. A flexible coupler, capable of absorbing torsional vibration, shall be employed between the pump and motor, and it shall be equipped with a suitable coupling guard.

## 3.3 INSTALLATION OF PUMP SUCTION DIFFUSERS

A. Following piping system cleaning and prior to balancing, remove start-up strainer.

B. Adjust support foot or base support boss to eliminate pipe strain at suction diffuser connection to pump.

## 3.4 ALIGNMENT

A. Comply with pump and coupling manufacturers' written instructions.

## 3.5 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.

D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.

E. Install check valve and shut-off valve on discharge side of pumps.

F. Install suction diffuser and shutoff valve on suction side of pumps on pumps with 3” and larger suction connection. Install shutoff valve on discharge of all pumps.

G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.

H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.

I. Install check valve and gate or ball valve on each condensate pump unit discharge.

J. Install electrical connections for power, controls, and devices.

K. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 232123

SECTION 232213 -STEAM AND CONDENSATE HEATING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and provisions of the Construction Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this Section.

1.2 SUMMARY

A. This Section includes the following for HP steam and condensate piping:

1. Pipe and fittings.
2. Strainers.
3. Flash tanks.
4. Safety valves.
5. Pressure-reducing valves.
6. Steam traps.
7. Thermostatic air vents and vacuum breakers.
8. Expansion Joints.

1.3 DEFINITIONS

A. HP Systems: High-pressure piping operating between 15 psig and 300 psig as required by ASME B31.1.

B. LP Systems: Low-pressure piping operating at 15 psig or less as required by ASME B31.9.

1.4 PERFORMANCE REQUIREMENTS

A. Components and installation shall be capable of withstanding the following minimum working pressures and temperatures:

1. High Pressure Steam, Condensate, and Vents.

a. Piping code: ASME B31.1
b. Pressure rating: ANSI Class 300
c. Design pressure: 300 psig
d. Design temperature: 421 °F
e. Operating pressure. 255 psig
f. Operating temperature: 410 °F
g. Ambient installation temperature: 20 °F minimum
h. Hydro-test pressure: 450 psig (in service and pneumatic testing or lower pressure allowed if approved in testing plan).
i. Pipe Expansion/Contraction: +3.14" / -0.16" (per 100 ft)

j. Number of cycles: steam 1,000 cycles, use B31.1 cyclic stress range factor =1.0.

2. Makeup-Water Piping: 80 psig at 150 deg F.
3. Blowdown-Drain Piping: Equal to pressure of the piping system to which it is attached.
4. Air-Vent and Vacuum-Breaker Piping: Equal to pressure of the piping system to which it is attached.
5. Safety-Valve-Inlet and -Outlet Piping: Equal to pressure of the piping system to which it is attached.

## 1.5 SUBMITTALS

A. Product Data: For each type of the following:

1. Valves
2. Strainers
3. Steam traps
4. Air vent and vacuum breaker.
5. Flash tank.

B. Shop Drawings: Detail, 1/4-inch equals 1-foot scale, flash tank assemblies and fabrication of pipe anchors, hangers, pipe, multiple pipes, alignment guides, and expansion joints and loops and their attachment to the building structure. Detail locations of anchors, alignment guides, and expansion joints and loops.

C. Welding Certificates: Submit Welding Procedure Specification (WPS) and welder or welding operator qualification records for approval before any welding is performed either in fabrication or on site. Records shall be available as required by ANSI/ASME Code for Pressure Piping, B31.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For valves, safety valves, pressure-reducing valves, steam traps, air vents, vacuum breakers, and meters to include in emergency, operation, and maintenance manuals.

## 1.6 QUALITY ASSURANCE

A. Conformance to design intent will be evaluated by the Engineer of Record. This will include inspection of records and observation of installation. Questions regarding design intent shall be addressed to the Engineer of Record.

B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify processes and operators according to the following:

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.

D. Examination will be performed by a third party retained by the Owner. Prepare piping for examination and notify construction manager and engineer when piping is ready for examination. Do not cover or insulate welded joints until accepted by the Owner.

E. Inspection will be the responsibility of the Owner. Contractor shall maintain records on site for inspection. These shall include qualified welding procedures, welder certifications, and equipment qualifications. Comply with inspector requests for records immediately.

F. System testing is the contractor's responsibility. Testing shall be done per ASME B31.1. and as indicated on the plans.

G. ASME Compliance:

1. The quality assurance, inspection, examination, and testing requirements of ANSI/ASME B31.1 shall apply to systems designed for 150 psig and 366°F or less.
2. The quality assurance, inspection, examination, and testing requirements of ANSI/ASME B31.1 shall apply to systems designed for greater than 150 psig and 366°F.
3. Welding examination is mandatory. Contractor shall coordinate and schedule examination by the Owner’s designated welding inspector.

H. Piping shall have identification affixed at the factory with proper ASTM identification. Piping specialties, including valves, shall have the manufacturer's trademark, name and/or model number and pressure rating, where applicable, affixed to permanently identify the manufacturer of product.

I. Welder shall mark each weld with unique identification, and mark shall be recorded in the Quality Control Records.

## PART 2 - PRODUCTS

### 2.1 STEEL PIPE AND FITTINGS

A. All steam piping components shall be cast or forge steel.

B. Steam Piping: Steel, ASTM A53, Grade B, seamless; or ASTM A106, Grade B, seamless. Wall thickness to be Schedule 80 for pipe 2” NPS and less, standard weight Schedule 40 for 2-1/2” NPS and larger.

C. Steam Condensate Piping, High-Pressure: Steel, ASTM A53, Grade B, seamless or ERW; or ASTM A106, Grade B, Seamless. Wall thickness to be Schedule 80 for pipe 2” NPS and less, Schedule 40 for 2-1/2” NPS and larger.

D. Unions: MSS-SP-83, 3000#, Threading per ANSI/ASME B1.20.1 NPT 1Class 300 for high pressure systems.

E. Bull Plug Fittings: MSS-SP-95, 6000#, solid, hex head, ASTM A 234, Grade WPB. Threading per ANSI/ASME B1.20.1 NPT 1. Class 300 for high pressure systems.

F. Forged Steel Fittings 1/2” to 2”, Socket Welding or Threaded: ASTM A105, ANSI/ASME B16.11, Class 3000. Threading per ANSI/ASME B1.20.1 NPT 1.

G. Forged Steel Fittings 2-1/2`” and Larger, Butt Welding: ANSI/ASME B16.9, ASTM A234 WPB, with same wall thickness as connecting piping unless noted otherwise. Elbows shall be long radius type, unless otherwise noted. Where connecting wall thickness is different fitting shall be back bored to match connecting wall thickness.

H. Wrought-Steel Flanges and Flanged Fittings: ASME B16.5, ASTM A105, including bolts, nuts, and gaskets of the following material group, end connections, and facings:

1. Material Group: 1.1.
2. End Connections: Butt welding, weld neck. Slip on allowed only where indicated.
3. Facings: Raised face, roughness 125 to 250 µ for spiral wound gasket applications.
4. Flanges shall be bored to match inside diameter of pipe.

I. Steel Pipe Nipples: ASTM A 733, made of ASTM A53, Grade B, seamless; or ASTM A106, Grade B, Seamless of same Type, Grade, and Schedule as pipe in which installed. Close Nipples are not allowed. Threading per ANSI/ASME B1.20.1 NPT 1.

J. Cast Iron Fittings: Not allowed.

K. Malleable-Iron Threaded Fittings: Not allowed.

## 2.2 JOINING MATERIALS

A. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated. Carbon steel stud bolts heavy hex nuts.

1. Bolts shall be per ASTM A193 GR B7
2. Hex nuts per ASTM A194 GR 2H heavy hex
3. Washers shall be: Type 1, circular, through hardened material and dimensions per ASTM F436 (2010), 38-45 HRC hardness. Washers shall be marked with a symbol indicating the type.
4. Lubricant: Nickel and graphite based anti-seize compound in grease carrier formulated to protect up to 2400°F against seizure, galling, galvanic and severe environmental corrosion. Never-Seez® Pure Nickel Special.

B. Composition Gaskets: Use only with flat face flange sets mating up to flat face cast iron equipment or valve connections. Gaskets shall be non-asbestos compressed material in accordance with ANSI/ASME B16.21, 1/16-inch thickness, full face type. The gaskets shall contain fibers bonded with nitrile butadiene rubber (NBR) rated for saturated and superheated steam service 750 degrees F and 1500 PSI.

1. Manufacturer: Garlock ST-706 or equal.

C. Semi-Metallic Gaskets: Gaskets shall be spiral wound type with external ring. Gasket shall conform to ASME B16.20 and be suitable for service indicated. The gasket shall be type 304 stainless steel spiral wound strip with flexible graphite or PTFE filler. Gasket thickness shall be manufacturer's standard thickness. Backing ring shall act as a compression stop and reinforcement for pressure containment.

1. Manufacturer: Garlock Flexseal RW or Flexitallic CG

D. Screwed Joints:

1. Pipe Thread: ANSI B1.20.1.
2. Lubricant or Sealant: Nickel and graphite based anti-seize compound in grease carrier formulated to protect up to 2400°F against seizure, galling, galvanic and severe environmental corrosion. Never-Seez® Pure Nickel Special.

## 2.3 VALVES

A. General:

1. Hard Facing: ASTM S182 F6/Stellite 6, or hardenable Martensitic Stainless steel A276 410, 420.
2. Testing: Per API 598
3. Flanged and Buttweld Design: ASME B16.34
4. Flange Dimensions: ASME B16.5
5. Flange Face-Face: ASME B16.10

B. Gate Valves 2" and smaller: Forged Steel OS&Y, API 602, ANSI Class 800, ASTM A105 or A105N body and bonnet, API Trim 603, seal welded bonnet, thread or socket weld end as indicated. Spiral wound gasket of AISI 316 or 304 stainless steel and graphite. Wedge seating surface and seats to be Stellite 6 hard faced. Stainless steel gland. Handwheel of ductile iron or steel.

1. Basis of design product: Velan 2054W.

C. Globe Valves 2" and Smaller: Forged Steel, ANSI Class 800, ASTM A105 or A105N body and bonnet, API Trim 602, bolted bonnet, thread or socket weld end as indicated. Spiral wound gasket of AISI 316 or 304 stainless steel and graphite. Disc and seats to be Stellite 6 hard faced. Stainless steel gland. Handwheel of ductile iron or steel. Seat rings will be acceptable with hard facing equivalent to integral seat.

1. Basis of design product: Velan 2074B.

D. Check Valves 2" and Smaller: Forged Steel ball check, ANSI Class 800, ASTM A105 or A105N body and bonnet, API Trim 602, bolted cover, thread or socket weld end as indicated. Spiral wound gasket of AISI 316 or 304 stainless steel and graphite. Integral hard-faced seat, ball of A276 440C or 420.

1. Basis of design product: Velan.

E. Gate Valves 2-1/2” -18”: Cast Steel OS&Y, ANSI Class 300, ASTM A216 WCB body and bonnet, API Trim 8, bolted bonnet, flanged ends. Spiral wound bonnet gasket of AISI 316 or 304 stainless steel and graphite. Hard face wedge seating surface and hard face seat rings with Stellite 6 per API Trim 5. Stainless steel gland. Handwheel shall be steel. Valves 12” NPS and larger shall have 90° gear box operator. Valves 8” and larger shall have bypass piping with globe valve.

1. Basis of design product: Velan 1064C.

F. Globe Valve 2-1/2” -18”: Cast Steel OS&Y, ANSI Class 300, ASTM A216 WCB body and bonnet, API Trim 8, bolted bonnet, flanged ends. Spiral wound bonnet gasket of AISI 316 or 304 stainless steel and graphite. Seat ring and disc Stellite 6 per API Trim 5. Stainless steel gland. Hand wheel shall be steel.

1. Basis of design product: Velan 1074C.

G. Check Valves 2-1/2” -18”: Cast Steel swing check, ANSI Class 300, ASTM A216 WCB body and bonnet, API Trim 594, bolted bonnet, flanged ends. Spiral wound bonnet gasket of AISI 316 or 304 stainless steel and graphite. Integral hard-faced seat, disk of CA 15 or 13Cr faced WCB.

1. Basis of design product: Velan.

H. High Performance Butterfly Valve 6”-16”: ANSI Class 300. B16.10 Short Pattern flanged, ASTM A216 WCB body and disc, Stellite Alloy 21 Seats, S17400 Shaft, Seal Stack 316SST solid, Graphite bearings, J.C. 3871, and Graphite Packing. Triple offset geometry, API 609 Conformance, Bi-directional sealing, Class V leakage per API 598, 50,000 cycles, Gear operator with allowable mounting at any 90° interval,

1. Basis of design product: Velan.

## 2.4 SAFETY VALVES

A. Cast-Steel Safety Valves:

1. Basis-of-Design Product: Consolidated 1900TD.
2. Disc Material: Type 616 Stainless steel.
3. End Connections: Raised-face flanged inlet and threaded or flanged outlet connections.
4. Spring: Fully enclosed cadmium-plated steel spring with adjustable pressure range and positive shutoff, factory set and sealed.
5. Pressure Class: 300.
6. Exhaust Head: Cast carbon steel body with stainless steel trim
7. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
8. Set pressures as indicated on drawings.

B. Drip-Pan Elbow: Carbon steel and having threaded inlet and outlet with threads complying with ASME B1.20.1.

1. Basis-of-Design Product: Keckley.

## 2.5 PRESSURE-REDUCING VALVES

A. Manufacturer: Spence.

B. Size, Capacity, and Pressure Rating: Factory set for inlet and outlet pressures indicated. Steam velocities not to exceed 10,000 fpm on the inlet and 3,000 fpm on the outlet. Valve rating: class 250 SWP.

C. Description: Pilot-actuated, diaphragm operated, packless, single seat, with adjustable pressure range and positive shutoff.

D. Body: Cast Steel with stainless trim, spring, and diaphragm.

E. End Connections: Flanged connections.

F. Trim: Hardened stainless steel.

G. Head and Seat: Replaceable, main head stem guide fitted with flushing and pressure-arresting device cover over pilot diaphragm.

## 2.6 STRAINERS

A. Construction: Strainers shall be Y-pattern, bodies of ample strength for the pressure to which they shall be subjected and suitable flanges or trappings to connect with the piping they serve. They shall be of such a design to allow blowing out of accumulated dirt and to facilitate removal and replacement of a strainer screen, without disconnections of the main piping.

B. Steam and Condensate Service:

1. 2" and Smaller: minimum, ASTM-A216 Gr. WCB cast steel body, wye-pattern, 3/64” perforation, AISI 304 stainless steel screen. Maximum operating condition 900 psig, 600°F or greater. Threaded end connections. Manufacturer: Spirax-Sarco Figure CT, Armstrong B-SC, Mueller 581, Keckley SB-7 or as approved.
2. 2-1/2" and Larger: Flanged, ANSI Class 300 minimum, ASTM-A216 Gr. WCB cast steel body, wye-pattern. AISI 304 stainless steel screen; 1/32" perforations for 2-1/2" to 3", 1/16" perforations for 4" and larger. Manufacturer: Armstrong No. B-FL-300, Spirax-Sarco no. 34, Mueller 782, Keckley SA-7 or as approved.

## 2.7 FLASH TANKS

A. Flash tanks are to be fabricated as steam piping assemblies and subject to examination, test, and inspection as such. Nonstandard piping components or plate fabrications are not allowed for pressure containing assemblies. See drawings for size and configuration.

## 2.8 EXPANSION JOINTS

A. Expansion Joints: externally pressurized type. Bellows material shall be 2-ply minimum Inconel 625 for steam service and Inconel 625 for condensate service. Provide with (2) socket weld drain connections at bottom of expansion joints. See Section 230516 Steam and Condensate Expansion Joints for additional requirements.

B. Expansion Hose: "US Hose" Inconel 625 hose core, single 321 SS braid, AISI 304 SS Male NPT ends, hex boss.

C. Exposed Bellows Types (Gimbal, Hinged, Tied Universal): 100% redundant plies, ply testable, two plies minimum for each bellows, Inconel 625 for steam service and Inconel 625 for condensate service. See Section 230516 Steam and Condensate Expansion Joints for additional requirements.

## 2.9 STEAM TRAPS

A. Basis-of-Design Product: Sterlco

B. Inverted bucket traps: The trap shall be of the inverted bucket type, with integral strainer, designed for use with a 360° universal connector. The entire trap body shall be fabricated from thin wall drawn stainless steel for enhanced freeze resistance. The trap shall employ a simple free-floating valve mechanism with no fixed pivots and no valve or bucket guides. The discharge valve shall be so attached to the valve lever that it is free to rotate for even wear distribution, and the valve and seat of the trap shall be lapped together as a matched set to insure tight shutoff. Use 250lb. #38 orifice for 200 lb system, 125lb. 1/8” orifice for 100 lb system and 70lb. 5/32” orifice for 30# system. Mounting Block by Armstrong. Provide Insu-Pak insulation package at all exterior trap locations. Armstrong # 2011-IS2 connection.

C. Float and Thermostatic traps: Cast iron body and bolted cap with maximum allowable and maximum working pressures not less than steam supply pressure. Renewable, stainless steel float mechanism with renewable, hardened stainless steel or chrome steel valve and valve seat; balanced-pressure, thermostatic air vent made with stainless steel or phosphor bronze bellows, and stainless-steel seat. Accessories: integral vacuum breaker. Armstrong B Series.

D. Applications.

1. Distribution piping: Inverted Bucket type traps sized for the anticipated steady state load at full line pressure differential with 2:1 safety factor. Trap Valve Station having integral isolation valves, strainer, and check valve is an acceptable alternate.
2. Drip leg is to be same size as steam line up to 4 inches. Above 4 inches, drip leg is to be half of steam line size, but not less than 4 inches. Inlet to steam trap shall be located at least 18 inches below steam line. Provide gate valve at bottom of drip leg to allow removal of dirt and scale.
3. Heat exchangers and heating coils: Inverted Bucket type sized for the maximum load at operating pressure with a 3:1 safety factor.

4. Modulated steam pressure: Float and Thermostatic type. Provide integral vacuum breaker. Drip legs should be a minimum of 12” vertical length. 0-15 psig steam: Size for maximum load at ½ psi differential with 2:1 safety factor. 16-30 psig steam: Size for maximum load at 2 psi differential with 2:1 safety factor. Above 30 psi steam: Size for maximum load at half of maximum pressure differential with 3:1 safety factor.

## 2.10 FLEXIBLE CONECTORS:

A. Flexible connectors shall be of flexible metal hose and braid type rated for steam service at system pressure. Flexible hose section to be stainless steel, corrugated hose with braided outer covering. Welded end connections to be carbon steel, 300 psi wsp.

1. Manufactures: Hyspan, Metraflex, Keflex.

## 2.11 THERMOSTATIC AIR VENTS AND VACUUM BREAKERS

A. Thermostatic Air Vents:

1. Basis-of-Design Product: Armstrong TTF Series.
2. Body: Stainless steel.
3. End Connections: Threaded.
4. Seat: Stainless steel.
5. Thermostatic Element: Phosphor bronze bellows in a stainless-steel cage.
6. Pressure Rating: 300 psig.
7. Maximum Temperature Rating: 450 deg F.

B. Vacuum Breakers:

1. Basis-of-Design Product: Armstrong
2. Body: Stainless steel.
3. End Connections: Threaded.
4. Valve, Spring, and Screen: Stainless steel.
5. O-ring Seal: EPDM.
6. Pressure Rating: 150 psig.

## 2.12 ANCILLARY PIPING APPLICATIONS

A. Air-Vent Piping:

1. Inlet: Same as service where installed.
2. Outlet: Type K annealed-temper copper tubing with soldered or flared joints.

B. Vacuum-Breaker Piping: Outlet, same as service where installed.

C. Safety-Valve-Inlet and -Outlet Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

A. Store materials to avoid excessive exposure to weather or foreign materials. Keep inside of piping clean during installation and protect open ends when work is not in progress.

B. Install piping generally parallel to walls and column center lines, unless shown otherwise on the drawings. Space piping, including insulation, to provide one-inch minimum clearance between adjacent piping and other surfaces. Unless shown otherwise, slope drain piping down in the direction of normal flow. Provide eccentric reducers to facilitate pipe draining. Reverse of pipe slope is allowed only by engineering approval and increase in pipe size a minimum of two sizes or as directed to reduce velocity to acceptable range.

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 to permit valve servicing.

E. Install piping to allow application of insulation.

F. Select system components with pressure rating equal to or greater than system operating pressure.

G. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

H. Install steam supply piping at a minimum uniform grade of 0.2 percent downward in direction of steam flow.

I. Install gravity condensate return piping at a minimum uniform grade of 0.4 percent downward in direction of condensate flow.

J. Reduce pipe sizes using eccentric reducer fitting installed with level side down unless indicated otherwise.

K. Locate and orient valves to permit proper operation and access for maintenance. Generally, locate valve stems in overhead piping in horizontal position. Provide a union adjacent to one end of all threaded end valves. Control valves usually require reducers to connect to pipe sizes shown on the drawing.

1. Valves in equipment rooms that are more than 8' above the floor (and not above a ceiling) shall be provided chain-operated sheaves and chains.
2. For chain-wheel operators, extend chains to 60 inches above finished floor elevation. Provide tie back hardware where chains obstruct walkways.
3. Steam branches from mains shall take off from top of pipe with isolation valve located in the horizontal position. Arrange and slope pipe so no condensate will accumulate at the closed valve. If valve must be installed in vertical position for clearance purposes provide drip leg and trap to prevent condensate accumulation.

L. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated unless noted otherwise.

M. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

N. Install strainers on supply side of control valves, pressure-reducing valves, traps, and elsewhere as indicated. Install NPS 3/4 nipple and gate valve in blowdown connection of strainers. Install strainers upstream of control valves and pressure reducing valves with "y" in horizontal plane to prevent trapping of condensate.

## 3.2 STEAM-TRAP INSTALLATION

A. Install steam traps in accessible locations where it will be convenient for periodic inspection and maintenance.

B. Steam traps shall be located to allow the condensate to flow into them by gravity as to provide positive drainage. The drain line to the trap shall pitch toward the trap without any air pockets. Each trap shall have a strainer and a dirt pocket installed ahead of the trap.

## 3.3 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 to full inside diameter 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. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate thread compound to external pipe threads unless dry seal threading is specified. Joint compound shall be applied to male threads only and joints made up so no more than three threads show. Coat exposed threads on steel pipe with joint compound for corrosion protection.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

E. Welded Joints: See Specification Section 232214 - CARBON STEEL PIPE WELDING

1. Welded, High Pressure Systems over 150 psi: Beveling, spacing and other details shall conform to ANSI/ASME B31.1 and ANSI/AWS B2.1. Welders shall be ASME certified. Make Welded joints without backing rings.

F. Coordinate and schedule inspection, examination, and testing with Owner designated inspector in compliance with ANSI/ASME B31.1. Inspection shall include fabrication, assembly, erection, and testing. Joints requiring examination shall include those indicated in ANSI/ASME B31.1 Chapter VI.

## 3.4 FLANGE ASSEMBLY

A. Assembly shall be made with all new materials.

1. Assembly shall include studs, nuts, washers under each nut, and lubricant.
2. Gaskets shall be new.
3. Studs greater than 1-1/8” may be approved by engineer for reassembly if originally installed with lubrication and in acceptable condition.

B. Preparation:

1. Clean flange faces with soft wire brush and if required solvent to remove residue.
2. Record location and size of damage to surface finishes and submit to engineer or designated inspector.
3. Record flange roughness at gasket contact surfaces using comparator gauges.
4. Number stud locations and identify tightening pattern and target torque for stud count. Patterns and target torque shall follow ASME PCC-1 (2010.)
5. Examine studs, nuts, and washers for burrs. Verify nuts are free running on studs. Stud length shall be sufficient to fully engage nuts.
6. Examine nut-bearing surfaces and washers for burrs, evidence of out-of-squareness and coatings. Clean and remove excessive coatings.
7. Verify flange alignment:

    a. Centerline: high/low, measure at four points on outside of flange, no variation greater than 1/16”.
    b. Parallelism: sealing surface gap shall not vary more than 1/32” with 10% or less bolt torque.
    c. Rotational: fasteners must be able to pass through matching holes at a 90° angle and holes must be aligned within 1/8” of perfect alignment.
    d. Excessive gap, flanges at rest shall not have a gap greater than twice the thickness of the gasket.

C. Assembly: Assembly will follow the single tool, pattern torque control method.

1. Install gasket and hold in flange center.
2. Install studs. Verify nuts are free running on studs. Stud markings shall be visible from tightening side.
3. Lubricate stud ends beyond point that nut will rest when tightened.
4. Lubricate nut contact faces.
5. Hand tighten nuts. No more than ½” of stud shall be exposed on the accessible end of the stud.
6. Pretension: Using tightening pattern, torque nuts 10 to 20 ft-lb but no more than 20% of target torque (550 ft-lb for coated 1-1/8” bolting).
7. Tightening:

a. After Round 1, 2, and 3 verify the flange gap around the circumference is uniform within 0.01”. Make adjustments by tightening and loosening. If the difference in torque is 50% or greater between all bolt positions, disassemble and find the source of misalignment.
b. Round 1 tighten to 20 to 30% of target torque.
c. Round 2 tighten to 50 to 70% of target toque Use Noncoated bolt target torque values (750 ft-lb for 1-1/8” bolting).
d. Round 3 tighten to 100% of target torque.
e. Round 4 tighten in circular clockwise pattern until no further nut movement occurs at Round 3 target torque value.
f. Wait four hours minimum, time permitting, and repeat round 4.
g. Target Torque Values for Low-Alloy Steel Bolting Based on Target Prestress of 50-ksi (Root Area):

| Nominal Bolt Size (Inches) | Lubricated Bolts (Foot – Lbs.) |
|---|---|
| 1/2 | 45 |
| 5/8 | 90 |
| 3/4 | 160 |
| 7/8 | 250 |
| 1 | 400 |
| 1/1/8 | 550 |
| 1 1/4 | 800 |
| 1 3/8 | 1,050 |
| 1 1/2 | 1,400 |
| 1 5/8 | 1,800 |

D. Make in service inspection of flanged joints for leakage after system reaches operating temperature and pressure.

## 3.5 EXPANSION JOINT INSTALLATION

A. Install pipe flanges at spacing indicated on drawings when pipe is at a stable temperature. Measure pipe temperature along run to determine average installed temperature. Flange alignment and spacing shall be as indicated. Do not use expansion joint to take up flange misalignment. Flange alignment must be as indicated under “Flange Assembly.”

B. Do not apply test pressures to expansion joint. Isolate both expansion joint flanges from pressure or remove joint prior to hydrostatic pressure test.

## 3.6 FIELD QUALITY CONTROL

A. See Specification Section 232214 CARBON STEEL PIPE WELDING for additional requirements.

B. Prepare steam and condensate piping according to ASME B31.1, "Power Piping" and as follows:

1. Coordinate with Owner’s examiner. Schedule testing for witness by Owner's representative or inspector.

2. Leave joints, including welds, uninsulated and exposed for examination during test.
3. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
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.

C. Test Methods:

1. Preliminary pneumatic test is not to exceed 25 psig and will be used to identify major leaks prior to initial service, test when rework after initial service test is deemed to be difficult by the Owner or Engineer of Record.
2. Steam piping shall be tested using an initial service test with examination of every joint.
3. Offsite shop fabricated piping spools shall be pressure tested to the required test pressure prior to sending to the field, as referenced ASME B31.1. Maintain test records at the fabrication site and the project site.

    a. Class 150 system test to 275 psig.
    b. Class 300 system test to 450 psig.

D. Do not cover piping with insulation until approved by the Engineer.

E. Hydrostatic test where applicable (offsite fabricated piping):

1. A corrosion inhibitor shall be used during hydrotesting to mitigate the effects of corrosion. The water source for hydrotesting shall be from the potable water distribution system operated by the municipal water system.
2. The corrosion inhibitor will be an Ammonium Benzoate based inhibitor such as Ashland Specialty Chemical Company's Protecsol or approved equal.
3. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing.
4. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Provide temporary valving or cap piping at connections to existing systems as required to confine testing to the new piping systems. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength. Provide temporary supports as required.
5. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the working pressure.
6. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks. System shall hold pressure for a minimum of two hours.

F. Prepare written report of testing.

END OF SECTION 232213

SECTION 233100 - METAL DUCTS AND CASINGS

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 metal ducts for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg and metal casings. Metal ducts include the following:

1. Rectangular ducts and fittings.
2. Single-wall, round spiral-seam ducts and formed fittings.
3. Duct liner.
4. Turning vanes.

B. Related Sections include the following:

1. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, and flexible ducts.

1.3 DEFINITIONS

A. FRP: Fiberglass-reinforced plastic.

B. NUSIG: National Uniform Seismic Installation Guidelines.

1.4 SYSTEM DESCRIPTION

A. Duct system design, as indicated, has been used to select size and type of air-moving and -distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by Engineer of Record. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

1.5 SUBMITTALS

A. Submit shop standard for ductwork construction utilized on this project. Include proposed duct gage, reinforcement interval, seam and joint construction for all sizes and pressure classes of rectangular, round, and oval ductwork. Submit construction standard for all plenums and fittings.

B. Field quality-control test reports.

## 1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports, AWS D1.2, "Structural Welding Code--Aluminum," for aluminum supporting members, and AWS D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance:

1. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
2. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

C. Duct Protection, Cleaning, and Cleanliness Testing: Comply with requirements in Part 3 of this specification for protection, cleaning, and cleanliness testing of ductwork.

# 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. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

## 2.2 GENERAL REQUIREMENTS –DUCTWORK AND PLENUMS

A. Construction: Primary air duct construction, fittings, reinforcements, pressure and seal classifications and metal gauges shall conform to SMACNA HVAC/DCS, 4th Edition and NFPA90A unless noted otherwise.

B. Ducts and accessories shall not pulsate or vibrate when in operation.

C. Test Ports: Provide instrument test holes with screw cap and gasket. Instrument test holes shall be attached to ducts and plenums with bolts. Seal around bolt head with duct sealant. Provide gasket to fit duct shape (rectangular or round) as needed. Provide all such test holes in ducts with instrument adapter as required for static pressure readings; exact location to be coordinated with air balancing contractor.

1. Available Manufacturer: Ventfabrics No. 699

D. Stuffing Boxes: Provide airtight stuffing boxes at all penetrations for instrumentation, such as sensors, thermostats, thermometers, pipes, etc.; use rubber grommets or U-channel rubber extrusions to create airtight seal.

1. Available Manufacturer: “Rubbercraft”.

E. At connections to building construction, use steel angles fastened to the sheet metal by sheet metal screws, attached using anchor bolts embedded in the wall or slab, with sealant under the angle, angles 2"x2"x3/16" minimum.

## 2.3 SHEETMETAL DUCTWORK

A. General: All ductwork shall be of sheet metal construction.

B. Pressure and Seal Classification: Unless otherwise indicated, construct ducts according to the following:

1. Supply ducts from outlet of air handlers and fans to terminal units: 6-in wg**.** Seal Class A.
2. Supply ducts downstream of terminal units: 2-in wg Seal Class A.
3. Return ducts: Negative 2-in wg, except ductwork from last volume damper to grille may be negative 1-in wg. Seal class A.
4. Exhaust ducts: Negative 2-in wg. Seal Class A.

C. Material schedule:

1. All ducts shall be galvanized steel unless otherwise specified.
2. Shower exhaust duct shall be made of aluminum to the first main connection.

D. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.

E. Aluminum: Type 3003-H14. Comply with requirements of ASTM B209.

1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 2005 HVAC/DCS, Article 1.12.1, "Conversion of Steel Tables to Aluminum".
2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 2005 HVAC/DCS, Table 3-3, "Aluminum Round Duct Gage Schedule." Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA Table 1-16 for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

F. Stainless Steel: Comply with ASTM A 480/A 480M, Type 304 OR 316L, cold rolled, annealed, sheet.

G. Flat oval ductwork is not permitted on exhaust or return systems.

H. Pressure classes refer to both positive and negative ducts in absolute numbers unless noted otherwise.

I. Round or Oval Elbow Construction: Round or oval segmented or mitered elbows shall be minimum 3-gore for 45°, 4-gore for 60°, and 5-gore for 90°. Adjustable round elbows are not permitted.

J. Bellmouth transitions shall be used on connections to air handling units and plenums.

K. Rectangular Elbows shall be radius or short radius with vanes, type RE 1 and RE 3 in the SMACNA manual. Mitered elbows with turning vanes and other types shall not be used, use short radius elbows with vanes where space is limited. Construct vanes per pages 4.5 and 4.6 (Figures 4-3 and 4-4) of the SMACNA manual.

L. Turning vanes for rectangular elbows:

1. Turning vanes shall be welded to runners at velocities exceeding 2,500 fpm.
2. All sheet metal duct pressure classes and velocities: Airfoil Turning Vane is acceptable. Non-adjustable, double wall 26-gauge hot dipped galvanized steel, true airfoil type air turning vanes at square duct elbows. Factory runner, 24-gauge, with vanes 2.4" o.c. Available Manufacturer: "Aero Dyne Company", Model HEP.
3. 2" wg. Pressure Class ducts or lower with velocities at or below 1500 fpm: 2" single width vanes, spaced 1.5" o.c. may be used when spanned lengths are 36" or less. Non-adjustable, single wall 24-gauge vane per SMACNA Fig. 4-3 & 4-4. Rail shall be 24-gauge. Available Manufacturer: "Duro Dyne", "Ductmate" Monorail.
4. 3" wg. Pressure Class or higher ducts at any velocity and where duct velocities in any pressure class exceed 1500 fpm: 2" double width vanes, spaced 2.125" o.c. shall be used when spanned lengths are 48" or less. This vane is acceptable at lower pressure classes and velocities. Non-adjustable, double wall 26-gauge vane per SMACNA Fig. 4-3 & 4-4. The 22-gauge vane runner shall be of the tabbed style and shall have bent, or winged tabs. Straight tabs are not permitted. Available Manufacturer: "C.L. Ward & Family Inc." Turning Vane and Speedy Rail, "Ductmate" Turning Vane and PROrail.
5. 3" wg. Pressure Class or higher ducts at any velocity and where duct velocities in any pressure class exceed 1500 fpm: 4.5" double width vanes, spaced 3.25" o.c. may be used when spanned lengths are 72" or less. Provide tie-rods for spans more than 72". This vane is acceptable at lower pressure classes and velocities. Non-adjustable, double wall 24-gauge vane per SMACNA Fig. Fig. 4-3 & 4-4. Vane runner shall be of the tabbed style and shall have bent, or winged tabs. Straight tabs are not permitted. Available Manufacturer: "C.L. Ward & Family Inc." Turning Vane and Speedy Rail, "Ductmate" PROrail.

M. Seams: All seams shall conform to SMACNA standards for the corresponding pressure and seal class and to the requirements in this specification.

1. Round and oval duct seams shall be spiral seam or continuous butt weld construction only.
2. Rectangular seams for 3-in wg pressure class or higher shall be SMACNA L-1 Pittsburgh Lock or continuous butt weld only.
3. Rectangular seams for 2-in wg pressure class or lower shall be continuous butt weld, SMACNA L-1 Pittsburgh Lock, or SMACNA L-2 Button Punch Snap Lock.
4. Do not use standing seams for ducts other than plenums

N. Joints: All joints shall conform to SMACNA standards for the corresponding pressure and seal class and to the requirements in this specification.

O. Rectangular Joints: Provide prefabricated slide-on transverse duct connectors and components. Install per manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcement(s). Formed-on SMACNA flanges T-25a (T.D.C.) or T-25b (T.D.F.) will not be accepted.

1. Acceptable Manufacturers:

   a. “Ductmate Industries” 25, 35, and 45
   b. “Nexus” G and J
   c. “W.D.C.I.” J and H

2. Rectangular joints for 2-in wg pressure class or lower may also be SMACNA

   a. T-24 flanged with gasket
   b. T-1 Drive Slip with T-5, T-6, T-10, T-11, or T-12 S Slip

P. Round Joints: Factory fabricated transverse spiral and round duct joints conforming to SMACNA standards RT-1 through RT-6 are acceptable for ducts 20” in diameter and under. Prefabricated connectors for duct joints are permitted as noted below. Install per manufacturer guidelines for sheet gauge, intermediate reinforcement size and spacing, and joint reinforcement(s).

1. 3”-14” Diameter: Install duct with a one piece round duct connector that includes a polyethylene gasket liner and single bolt closure. “Ductmate Industries” Quick-Sleeve Round Duct Connector, “Ward Industries” Quick Connect Model QCC (up to 12” only) or approved equal.
2. 14”-72” Diameter: Install duct using a three-piece, gasket flanged joint consisting of two internal flanges, with integral mastic sealant and one external closure band, which compresses the gasket between the internal flanges. “Ductmate Industries” Spiralmate or approved equal.

Q. See Low Pressure Duct Requirements detail on drawings for acceptable configurations for offsets, transitions, and take-offs.

R. Diagonal Creasing for ducts 3-in wg or lower: Provide on all panels wider than 18". At Contractor's option, in place of diagonal creasing required for panels wider than 18", all such panels may have machine-formed transverse ribbed stiffening on 12" centers, provided such stiffening accomplishes stiffness and freedom from buckling or breathing, and does not lessen airtightness at seams and joints.

S. 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.

T. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Characteristics: Type S, Grade NS, Class 25, Use O.
3. If low-emitting materials are required for LEED-NC Credit EQ 4.1: use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

U. Gaskets in Flanged Ducts: Use soft neoprene or extruded butyl.

## 2.4 DOUBLE-WALL DUCT AND FITTING FABRICATION

A. Manufacturers:

1. Lindab Inc.
2. McGill AirFlow Corporation (K-27)
3. PTM Dual-Tech
4. Or equal.

B. Ducts: Fabricate double-wall (insulated) ducts with an outer shell and an inner duct. Dimensions indicated are for inner ducts.

1. Outer Shell: Base metal thickness on outer-shell dimensions. Fabricate outer-shell lengths 2 inches longer than inner duct and insulation and in metal thickness specified for single-wall duct.
2. Insulation: 2-inch- thick fibrous glass. Terminate insulation where double-wall duct connects to single-wall duct or uninsulated components and reduce outer shell diameter to inner duct diameter.

   a. Thermal Conductivity (k-Value): 0.26 at 75 deg F mean temperature.

3. Solid Inner Ducts: Use the following sheet metal thicknesses and seam construction:

   a. Ducts 3 to 8 Inches in Diameter: 0.019 inch with standard spiral-seam construction.
   b. Ducts 9 to 42 Inches in Diameter: 0.019 inch with single-rib spiral-seam construction.
   c. Ducts 44 to 60 Inches in Diameter: 0.022 inch with single-rib spiral-seam construction.
   d. Ducts 62 to 88 Inches in Diameter: 0.034 inch with standard spiral-seam construction.

4. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent. Provide Mylar or Tedlar layer to separate insulation from air stream.
5. Maintain concentricity of inner duct to outer shell by mechanical means. Prevent dislocation of insulation by mechanical means.

C. Fittings (from minus 2- to plus 10-inch wg): Fabricate double-wall (insulated) fittings with an outer shell and an inner duct.

1. Solid Inner Ducts: Use the following sheet metal thicknesses:

a. Ducts 3 to 34 Inches in Diameter: 0.028 inch.
b. Ducts 35 to 58 Inches in Diameter: 0.034 inch.
c. Ducts 60 to 88 Inches in Diameter: 0.040 inch.

2. Perforated Inner Ducts: Fabricate with 0.028-inch- thick sheet metal having 3/32-inch-diameter perforations, with overall open area of 23 percent. Provide Mylar or Tedlar layer to separate insulation from air stream.

## 2.5 FUME EXHAUST DUCTWORK

A. General: Provide all sheet metal work for the fume exhaust systems serving fume hoods, bio-safety cabinets, and general lab room exhaust (when tied into fume exhaust). Comply with SMACNA Round Industrial Duct Construction Standards AND/OR SMACNA Rectangular Industrial Duct Construction Standards unless noted otherwise.

B. Material: Type 316L stainless steel not to exceed 0.03% carbon OR 304 stainless steel. Sheet metal shall bear visible manufacturer's inscriptions on exterior of duct and fittings. For exposed work, inscription shall remain until time of final cleanup at site of exposed surfaces.

C. Subcontractor: All work shall be done by a subcontractor who has substantial experience in the fabricating of high quality welded stainless-steel sheet metal work; as approved by the A/E, before starting fabrication. Skilled welders only shall be employed; shall each hold a currently active certificate, dated within 12 months, from a recognized testing laboratory, indicating satisfactory welding test results per the American Welding Society D9.1M/D9.1:2000 or ASME Boiler and Unfired Pressure Vessel Code, Section IX, Welding Qualifications. Retest is required if welder has not performed welding for a period of 90 days. Also, if, in the opinion of the Owner’s Representative, the work of any welder creates a reasonable doubt as to their skill, additional tests may be ordered by the Owner at the Contractor's expense. The Owner or their representative reserve the right to observe duct construction in the shop or in the field.

D. Welds shall be thoroughly fused and otherwise sound throughout. Contours shall be uniform with regular even ripples. Surfaces shall not be dressed, smoothed, or otherwise finished to improve their appearance, except as necessary to correct defects. Welds shall be free from gas pockets, oxides, slag inclusions, and porosity. Welds shall be free from overlaps, undercuts, and excessive convexity. Internal surfaces of pipe and fittings shall be free from weld globules or other inward protrusions at welded joints or seams.

E. Only stainless-steel tools (hammers, brushes) shall be used when working with ductwork.

F. Defective welds will not be accepted. Defective welds are those that fail to comply with AWS D9.1M/D9.1:2000, and those which result in leakage during testing of piping. Defective welds shall be corrected by the Contractor at no additional cost to Owner. Ducts and fittings with defective welds that cannot be satisfactorily corrected, as determined by the Owner’s Representative, shall be replaced with new ducts and fittings at no additional cost to the Owner.

G. Protect all ductwork from scratches. Replace all scratched ductwork.

H. Duct sizes refer to inside diameter, and dimensions of ducts.

I. Offsets in Ductwork: The drawings do not show all offsets that may be required. Make offsets with fittings with as small an angle of offset as possible. Obtain engineer approval for all offsets over 15 degrees.

J. Gauge: Gauge shall permit welding without distortion and shall be No. 18 minimum for ducts 22" diameter and smaller. Ducts larger than 22" shall be 16-gauge minimum.

K. Finish: In finished building areas visible to occupants of building, all exposed surfaces of ducts, elbows, and other fittings shall be Finish No. 4, exposed surfaces of welds ground and polished to match, in mechanical areas and concealed spaces and outdoor ducts, No. 2-B, 2-D, or 4 finish.

L. Seams and Joints: Continuously butt-welded using gas tungsten arc welding (GTAW/TIG) and pure argon gas shielded welding methods. Shield rear side of weld as well as weld side with argon. There shall be minute or no oxidation. Furnish temporary bulkheads, barriers, and closures for inert shield gas and remove such bulkheads, barriers, and closures after welding is complete. Gas metal arc welding (GMAW/MIG/wire feed) is not acceptable.

M. Fittings and transitions shall conform to the following requirements, regardless of how they are diagrammatically show on the drawings:

1. Elbows: Smooth-flow long radius pattern, centerline radius at least 1-1/2 times the diameter or depth of the duct in the plane of the turn, and a minimum 5-gores.
2. Transitions and Reducing Fittings: Tapered, with a 15° included angle.
3. Side connections to ducts shall join the main duct at a 30-45° angle.

N. Capped Outlets for Future Connections: 22-gauge, stainless steel of same material as the duct, tightly fitted; mastic in joint.

O. Connection to Hoods: Tight slip fit, 3" insertion, with fire-retardant adhesive; stainless steel rivets; shall match the hood outlet size. Slope to drain back to fume hood.

P. Plenums: For plenums at inlet and discharge of fume exhaust fans or where indicated, same type of stainless steel as duct, 16-gauge minimum, all joints butt-welded. Provide welded stainless-steel support frames and angles, anchored to building structure.

Q. Roof Mounted Ductwork: Provide flashings over roof penetrations. Provide roof caps and terminations as shown. Bracing and supports shall be welded steel, hot dip galvanized. Provide neoprene barrier between stainless duct and non-stainless roof supports. Provide screen for each outlet with 2x2 mesh per inch, 15-gauge stainless steel screen.

R. Base Drains: At low points in ducts, provide a Type 316L stainless steel nipple, Schedule 40 pipe, with threaded end, in bottom of duct.

S. Ductwork shall be supported in accordance with SMACNA HVAC Duct Construction Standards and ACGIH Industrial Ventilation Manual, except as indicated and otherwise specified. Hangers shall be stainless steel.

## 2.6 SHEETMETAL MATERIALS

A. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.

B. Aluminum: Type 3003-H14. Comply with requirements of ASTM B209.

1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 1995 HVAC/DCS, Article 1.12.1, "Conversion of Steel Tables to Aluminum".
2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 1995 HVAC/DCS, Table 3-3, "Aluminum Round Duct Gage Schedule". Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA Table 1-16 for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

C. Stainless Steel: Unless indicated otherwise, Type 316L stainless steel, not to exceed 0.03% carbon, conforming to ASTM A240/A240M.

## 2.7 CANOPY HOODS

A. Condensate hoods shall be of the Type II, exhaust only canopy.

B. The hood(s) shall be constructed of a minimum of 18 gauge 400 series stainless. The hood(s) shall be constructed using the standing seam method for optimum strength. All seams, joints and penetrations of the hood enclosure shall be welded and/or liquid tight. Lighter material gauges, alternate material types and finishes are not acceptable.

C. The hood(s) shall include a full perimeter, welded, condensate collecting gutter with a 0.5 inch N.P.T. stainless steel drain fitting.

D. The canopy hood(s) shall be built in accordance with the NFPA 96, IMC, and bear the NSF Seal of Approval.

# PART 3 - EXECUTION

## 3.1 DUCT INSTALLATION

A. Fabricate and install ductwork and accessories in accordance with SMACNA Duct Construction Standards, Metal and Flexible.

1. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, terminal units, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide necessary fittings and offsets at no additional cost to the owner. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions, which shall be altered by the contractor to other dimensions with the same air handling characteristics (not less than same free area and pressure drop) where necessary to avoid interferences and clearance difficulties.
2. Comply with the requirements of Section 230500, "Transitions and Offsets Beyond the Scope of Work".

B. Provide Duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Duct Construction Standards, Metal and Flexible and with Duct Fitting Requirements detail on drawings.

1. When an obstruction cannot be avoided and must be taken in by the duct, comply with SMACNA “Obstructions". Repair galvanized areas with galvanizing repair compound.
2. Construct casings, plenums, eliminators, and pipe penetrations in accordance with SMACNA Standards, install plenum access doors to swing against air pressure so that pressure helps to maintain a tight seal.

C. Install round and flat-oval ducts in lengths not less than 12 feet unless interrupted by fittings.

D. Install ducts with fewest possible joints.

E. Provide test holes at fan inlets and outlets, where required for balancing, and elsewhere as indicated.

F. Install fabricated fittings for changes in directions, size, and shape and for connections.

G. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12 inches, with a minimum of 3 screws in each coupling.

H. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs.

I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

K. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

L. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

M. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

N. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

O. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1-1/2 inches.

P. Paint interiors of metal ducts that do not have duct liner, for 24 inches upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

Q. New Ductwork Protection and Cleaning:

1. Each piece of shop-fabricated ductwork shall be cleaned of contaminants and oil residue before being sent to the job site.
2. Each piece of field-fabricated ductwork shall be cleaned of contaminants and oil residue It shall then either be promptly installed or sealed with visqueen or "Ductcap Products Inc" caps and stored.
3. All ductwork stored on the jobsite shall remain sealed until it is installed. Unsealed sections of ductwork shall not be permitted to be stored or lying about the jobsite.
4. All ductwork shall always be protected from moisture.
5. All ends of installed ductwork shall be sealed with visqueen or "Ductcap Products Inc" caps at the end of each workday.

R. New Ductwork Protection and Cleaning (Lab Rooms):

1. Each piece of shop-fabricated ductwork shall be wiped down with alcohol on the inside after being cleaned of contaminants and oil residue, and then sealed with visqueen or "Ductcap Products Inc" (or similar) caps before being sent to the job site.
2. Each piece of field-fabricated ductwork shall be wiped down with alcohol on the inside after being cleaned of contaminants and oil residue. It shall then either be promptly installed or sealed with visqueen or "Ductcap Products Inc" caps and stored.

S. Existing Ductwork Protection and Cleanliness Evaluation:

1. All ends of existing ductwork that are exposed after demolition shall be sealed with visqueen at the end of each workday.
2. Notify A/E when the majority of existing ductwork demolition has been completed and remaining existing ductwork is available for evaluation. The Owner or their designated representative will evaluate the cleanliness of the existing ductwork. The Owner may then elect to hire a contractor to clean the existing ductwork before connections are made to the new system.

T. Ductwork Cleanliness Testing:

1. The Owner or their designated representative will visually observe the metal ducts for oil residue and contaminants. Where contaminants are discovered visually or by a white-glove test, the contractor is responsible for re-cleaning the ductwork before re-evaluation. Notify A/E when the majority of new ductwork has been installed, but before terminal units are connected and again before flexible ducts and diffusers are connected.
2. At the discretion and expense of the Owner, sections of metal duct system, chosen randomly by Owner, may be tested for cleanliness according to NADCA Standard 1992-01utilizing NIOSH Method 0500 vacuum test gravimetric analysis for total nuisance dust.

    a. If analysis determines that levels of debris are equal to or lower than suitable levels (5.0 $mg/m^3$ of particulates), the system shall have passed cleanliness verification.
    b. If analysis determines that levels of debris exceed suitable levels, system cleanliness will have failed, and the metal duct system shall be re-cleaned and re-tested at the Contractor's expense. .

## 3.2 SEAM AND JOINT SEALING

A. Seal duct seams and joints according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" for duct pressure and seal class indicated in Part 2 of this specification section.

B. Seal ducts before external insulation is applied.

C. Adhesive-backed cloth or metallic furnace tape will not be acceptable.

## 3.3 CONNECTIONS

A. Make connections to equipment with flexible connectors according to Division 23 Section "Air Duct Accessories."

## 3.4 FIELD QUALITY CONTROL

A. Air Supply and Distribution Systems: The air supply, return, and exhaust and distribution systems and its components shall be given an operational test.

B. Leakage Testing of Ductwork: Perform the following field test and inspections according to SMACNA "HVAC Air Duct Leakage Test Manual", prepare test reports, and submit for approval. Include final reports in the O&M Manual:

1. Perform preliminary duct leakage test when ductwork is between 15% and 30% complete. The engineer shall select the section(s) of ductwork to be tested or may elect to test all installed ductwork.
2. Perform final duct leakage test of complete system, including supply, return, relief, and exhaust ductwork, section by section, including fans, coils, and filter sections.
3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.

4. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, request clarification from the Engineer before constructing ductwork. Do not pressurize systems above maximum design operating pressure. Give seven days written advance notice for testing. Testing shall be repeated if conducted without required notice.
5. Maximum Allowable Leakage for all ductwork excluding welded stainless-steel ductwork: Pressure classes refer to both positive and negative in absolute values. Note that some of these requirements exceed default SMACNA leakage class values. Comply with requirements for Leakage Class 3 for round ducts, Leakage Class 12 for rectangular ducts in pressure classes lower than and equal to 2-inch w.g., and Leakage Class 6 for pressure classes from above 2-inch to 10-inch w.g.
6. Remake leaking joints and retest until leakage is equal to or less than maximum allowable.

C. Leakage testing of welded stainless-steel fume and biosafety cabinet exhaust ductwork:

1. Perform testing, prepare test reports, and submit for approval. Include final reports in the O&M Manual. Notify TAB Contractor, Commissioning Agent, and Engineer at least 2 weeks in advance of testing date so that they may attend and witness the test.
2. Test per ASME N510. The basic procedure for ductwork pressure decay testing is as follows. See ASME N510 for additional criteria.
3. Submit certificates of calibration for review at least 2 weeks before test is performed.
4. Isolate and seal the ductwork to be tested.
5. Attach a temperature and pressure sensor to the test system to indicate interior temperature and pressure. Note that it is best to perform the test before sunrise so that varying temperatures due to solar gain are minimized.
6. Pressurize ductwork with air to at least 2” wg and allow to stabilize.
7. Record temperature inside the ductwork at beginning and end of the test.
8. Dynamically trend pressure loss; record at 10 second intervals for minimum of 30 minutes.
9. The acceptance criteria outlined below must be satisfied (note: sources of air leakage can be identified using a soap or commercial detector solution on joints, corners, sealed penetrations, etc.)
10. Ductwork acceptance criteria: Rate of air leakage not to exceed 0.2% of duct vol/min at 2” w.g.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233100

SECTION 233300 – AIR DUCT ACCESSORIES

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. Volume dampers.
2. Motorized dampers.
3. Duct-mounted access doors.
4. Casing and Plenum access doors.
5. Flexible connectors.
6. Flexible ducts.

B. Related Sections include the following:

1. Division 23, Section 230900, "Instrumentation and Control for HVAC" for damper actuators.
2. Division 23, Section “HVAC Ductwork and Casings” for test ports, stuffing boxes, turning vanes, joint sealant, and safety relief access doors.

1.3 SUBMITTALS

A. Product Data: Submit for the following:

1. Volume dampers.
2. Motorized dampers.
3. Duct-mounted access doors.
4. Casing and plenum access doors.
5. Flexible connectors.
6. Flexible ducts.

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. Manual volume damper installations.
2. Motorized dampers installation including actuator location and accessibility.
3. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling plans, drawn to scale and coordinating penetrations and ceiling-mounting items. Show ceiling-mounting access panels and access doors required for access to duct accessories.

## 1.4 QUALITY ASSURANCE

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

# PART 2 - PRODUCTS

## 2.1 SHEETMETAL MATERIALS

A. Galvanized Steel: Steel sheets, G-60 zinc-coated (galvanized) or zinc-iron alloy coated (galvannealed) by the hot dip process, conforming ASTM A653 unless noted otherwise.

B. Aluminum: Type 3003-H14. Comply with requirements of ASTM B209.

1. Rectangular Ductwork: Aluminum ductwork shall comply with the requirements of low pressure galvanized steel ductwork. Thickness adjustments of aluminum, including dimension adjustments and reinforcements needed to meet the construction requirement thickness of steel ducts, shall comply with SMACNA 2005 HVAC Duct Construction Standards, Article 2.10.1, "Conversion of Steel Tables to Aluminum".
2. Round Ductwork: Construction of aluminum duct and fittings shall otherwise correspond in the same relationship as for steel duct. Conform to SMACNA 2005 HVAC Duct Construction Standards, Table 3-14, "Aluminum Round Duct Gage Schedule". Aluminum fasteners shall be used. Structural members shall be alloy 6061-T6 or galvanized steel as related in SMACNA for rectangular duct. Hangers in contact with the duct shall be galvanized steel or aluminum.

C. Stainless Steel: Unless indicated otherwise, Type 316L stainless steel, not to exceed 0.03% carbon, conforming to ASTM A240/A240M.

## 2.2 VOLUME DAMPERS

A. General Description: All volume dampers shall be factory fabricated with hardware and accessories. Stiffen damper blades for stability and include locking device to hold single-blade dampers in a fixed position without vibration. Dampers shall be free from any sharp edges that would produce excessive turbulence. Dampers must be rated for the service pressure drop, velocity, and temperature.

B. Damper and Accessory Material: Same as metal duct.

C. Single Blade Volume Dampers:

1. Permitted only for rectangular ducts up to 36” wide and 12” high or round ducts up to 12” diameter.

2. Rated for velocities up to 1500 fpm and pressure drops across damper of 1 in. wg. or less.
3. Damper blade shall be minimum 22-gauge steel and shall be as close to full size as possible without binding. Both leading and leaving edges hemmed; side edges flanged 1/2"; placed so air strikes the smooth face.
4. Damper shaft shall be minimum 3/8” square rod. Shafts shall be full length.
5. Frame shall be min. 20-gauge steel channels with mitered and welded corners.
6. Basis of Design: McGill AirFlow Corporation Models UVC8 and UVC9.
7. Manufacturers:

    a. McGill AirFlow Corporation Models UVC8 and UVC9.
    b. Greenheck Models MBD-10 and MBDR-50
    c. Ruskin
    d. Young Regulator Company

D. Rectangular and Square Opposed-Blade Volume Dampers:

1. Provide for rectangular ducts over 36” wide or 12” high or round ducts over 12” diameter and where specifically designated on the drawings.

    a. May be used in place of single blade volume dampers at contractor’s option.
    b. Rated for velocities up to 2000 fpm and pressure drops across damper of 2 in. wg. or less.
    c. Damper must be rated for the service pressure drop, velocity, and temperature.

2. Round ducts shall be provided with transitions into and out of the square damper assembly.
3. Damper blades shall be minimum 16-gauge galvanized steel. Both leading and leaving edges hemmed; side edges flanged 1/2"; placed so air strikes the smooth face.
4. Damper shafts shall be minimum 1/2” square rod. Shafts shall be full length.
5. Frames shall be min. 16-gauge galvanized steel structural or formed channels with mitered and welded corners.
6. Basis of Design: McGill AirFlow Corporation Model UVC21.
7. Manufacturers:

    a. McGill AirFlow Corporation Model UVC21
    b. Greenheck Model VCD-18
    c. Ruskin
    d. Young Regulator Company

E. Bearings:

1. Provide end bearings or other seals for ducts with axles full length of damper blades and bearings at both ends of operating shaft.
2. Bearings shall be molded synthetic, oil-impregnated bronze, Zytel, or stainless steel.
3. Basis of Design: Ventfabrics HiVel Ventlok.
4. Manufacturers:

    a. Ventfabrics HiVel Ventlok
    b. Young Regulator Company

F. Quadrants:

1. Provided with a dial regulator, heavy gauge handle, and locking nut. Size to match shaft size.
2. Provide elevated stand-off for use on all externally insulated ductwork.
3. Basis of Design: Ventfabrics Ventline Quadrant.
4. Manufacturer:

    a. Ventfabrics Ventline Quadrant
    b. Young Regulator Company

G. Quadrants for Dampers in Ducts Concealed Behind Walls and Above Non-Removable Ceilings:

1. Direct Controlled Dampers: Where possible, use direct controlled dampers. Damper regulator shall be cast into a box for flush mounting in ceilings. Cover telescopes into base to allow for expansion. Cover shall be secured by two screws to facilitate removal for adjustment of the damper. The regulator shall be made to accommodate 3/8" and 1/2" square rod.

    a. Basis of Design: Young Regulator No. 301
    b. Manufacturers:

        1) Young Regulator No. 301
        2) Ventfabrics No. 666
        3) Ruskin
        4) Nailor

2. Cable Controlled Dampers: Balancing dampers in ducts concealed behind walls and non-removable ceilings shall be provided with cable-controls if access to the regulator cannot be immediately adjacent to the damper. Damper controller and cable shall be concealed above the ceiling. Cable shall consist of Bowden cable 0.054" stainless steel control wire encapsulated in 1/16" flexible galvanized spiral wire sheath. Control kit shall consist of 2-5/8" diameter die cast aluminum housing with three-inch diameter cover, and 14-gauge steel rack and pinion gear drive converting rotary motion to push-pull motion. Control kit shall be imbedded in the ceiling flush with the finished surface. Control kit shall be manually operated with a wrench.

    a. Basis of Design: Young Regulator Model 270-301 control kit and Model 030-12 wrench
    b. Manufacturers:

        1) Young Regulator Model 270-301 control kit and Model 030-12 wrench.
        2) Ventfabrics

## 2.3 MOTORIZED DAMPERS

A. Control Dampers: AMCA-rated, opposed blade design; 0.125-inch minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall be heavy gage extruded aluminum, airfoil type, with maximum blade width of 6 inches and length of 48 inches.

1. Secure blades to 1/2-inch diameter, zinc-plated axles using zinc-plated hardware, blade-linkage hardware of zinc-plated steel and brass, ends sealed against molded synthetic blade bearings.
2. Operating Temperature Range: From minus 40 to plus 200 deg F.
3. Edge Seals, Low-Leakage: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than 8 cfm per sq. ft. of damper area at differential pressure of four inch w.g. and a maximum of 3 cfm per sq.ft. at one inch w.g. when tested according to AMCA 500D.

B. Large damper assemblies shall be made of individually driven segments that are small enough to ensure reliable operation and uniform closure across the entire damper assembly. Actuators shall be operated independently so that if one damper segment or actuator becomes inoperable, the others remain operable (provide multiple end switches wired together so if a section fails, end switch will acknowledge). Jack shafts and linkages should not be necessary and can only be used if approved by Owner.

C. See the failure mode section above for actuator responses under failure due to loss of power, loss of control air, or loss of communication. Where an actuator is to fail open or fail closed, provide spring return. Actuators shall not be dependent on batteries or capacitors to stroke to the power fail position upon loss of power.

D. Permanently stamp or scribe position indication on the end of driven shaft unless damper is visible from same location as end of shaft.

E. Actuators: See Section 230900 - INSTRUMENTATION AND CONTROL SYSTEMS.

1. Basis of Design: Ruskin Industries Model CD50.
2. Manufacturers:

a. Greenheck
b. Titus
c. Kreuger

## 2.4 DUCT-MOUNTED ACCESS DOORS

A. General Description: Fabricate doors airtight and suitable for duct pressure class.

B. Rectangular Duct Door: Double wall, duct mounting, and rectangular; fabricated of galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class. Include vision panel where indicated**.** Include 1-by-1-inch butt or piano hinge and cam latches.

1. Basis of Design: Ductmate Industries, Inc. “Square Framed Access Doors, Hinged and Cammed Model”.
2. Manufacturers:

a. Ductmate Industries, Inc. “Square Framed Access Doors, Hinged and Cammed Model”.
b. Air Balance Inc. “Series FSA”
c. Greenheck
d. McGill AirFlow Corporation Model ARB
e. Ruskin “SMACNA Standard”

3. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
4. Provide number of hinges and locks as follows:

a. Less Than 12 Inches Square: Secure with two sash locks.
b. Up to 18 Inches Square: Two hinges and two sash locks.
c. Up to 24 by 48 Inches: Three hinges and two compression latches**.**
d. Sizes 24 by 48 Inches and Larger: One additional hinge.

C. Round Duct Door: Double wall, duct mounting, and round; fabricated of galvanized sheet metal with insulation fill and 1-inch thickness. Include cam latches.

1. Basis of Design: Ductmate Industries, Inc. “Sandwich Access Door”.
2. Manufacturers:

a. Ductmate Industries, Inc. “Sandwich Access Door”
b. McGill AirFlow Corporation

3. Frame: Galvanized sheet steel, with spin-in notched frame.

D. Seal around frame attachment to duct and door to frame with neoprene or foam rubber.

E. Insulation: One-inch- thick, fibrous-glass or polystyrene-foam board.

2.5 Access Doors in Casings and Plenums:

A. Construct in accordance with SMACNA 2005 HVAC Duct Construction Standards, Fig. 9-16. Doors shall be double-wall insulated type and shall be equipped with three heavy duty zinc plated steel strap type T-hinges and two latches with lever handle on outside and inside. Doors shall be gasketed.

1. Basis of Design: Ductmate Industries, Inc. “Square Framed Access Doors, Hinged and Cammed Model”
2. Manufacturers:

a. Ductmate Industries, Inc
b. Ventfabrics, Inc. "Ventlok"
c. Air Balance, Inc. Series FSA

B. Latches shall have lever handle and stud to accommodate door thickness with inside beveled flange to work against door frame to give compression. Latch escutcheon shall be sponge rubber gasketed, heavy duty zinc plated steel

C. Walk-in access doors in casing and plenum walls shall be minimum 20" x 72" size.

## 2.6 FLEXIBLE CONNECTORS

A. Basis of Design: Ductmate Industries, Inc. “Proflex”.

B. Manufacturers:

1. Ductmate Industries, Inc. “Proflex”
2. Ventfabrics, Inc. “Ventglas” (Indoor Installations) and “Ventlon” (Outdoor Installations).
3. Duro Dyne Corp.

C. General: Provide fabric-type flexible connectors between fans and ducts or casings, fans, and plenums, and where ducts are of dissimilar metals, as indicated and where required. Fabric shall comply with UL Standard 214 and shall be accepted by NFPA for vibration isolation connectors in duct systems per NFPA Standard 90.

D. Connectors at Indoor Installations: Connectors shall be made of heavy glass fabric double-coated with neoprene, weighing approximately 30 oz. per square yard. Flexible connections shall be securely fastened by zinc-coated iron cinch-type draw bands for round ducts. For rectangular ducts, the flexible connections locked to metal collars shall be installed using normal duct construction standards and according to SMACNA 2005 HVAC Duct Construction Standards.

E. Connectors at Outdoor Installations: Connectors shall be same as specified for indoor installations except fabric shall be made of heavy glass fabric double coated with Hypalon, weighing approximately 26 oz. per square yard.

## 2.7 FLEXIBLE DUCTS

A. Manufacturers:

1. Flexmaster U.S.A., Inc. 1M or approved.

B. General: Flexible duct, including connectors, shall comply with UL181, Class I, and NFPA 90A and shall have acoustical performance acceptable to the Engineer. Installed duct shall not erode, delaminate, or impart loose fibers or odors into the air stream. Internal positive working pressure shall be +10 in. w.g. Internal negative working pressure shall be -5 in. w.g. through 16" diameter and –1 in. wg. at 18" and 20" diameter.

C. Materials: Flexible duct assembly shall consist of a strong and puncture resistant polyethylene inner liner and a high strength duct wall, mechanically locked together with a corrosive resistant galvanized helix to form a solid performing UL-181, Class 1 flexible duct, without the use of glue or adhesives.

D. Insulation and Vapor Barrier: The factory-fabricated flexible duct shall have blanket-type insulation, having a C Factor of not more than 0.23. The insulation shall be sheathed with a reinforced metallized vapor barrier having a maximum permeability of 0.05 perm per ASTM E96, Procedure A. The vapor barrier jacket on the flexible duct shall be sealed to vapor barrier on the connecting sheet metal ducts. Joints shall be airtight slip joints sealed and secured with a clamp.

E. Clamps: 175-lb test 6/6 nylon locking draw band at each end.

1. Manufacturer: Panduit SLT10-LH-L, Ideal "Snaplock" or Ventlock "Suretite" No. 670.

F. Acoustical Performance: Test reports from an independent laboratory showing that flexible ducts meet the performance specifications stated below. If manufacturer other than that specified is submitted, provide acoustical performance ratings for each size flexible duct. Acoustical performance testing shall be performed by an independent laboratory. The specified insertion loss and radiated noise reduction of flexible duct should be met when tested with a 6-foot length of straight duct less than 500 feet per minute velocity.

| Type 1M INSERTION LOSS (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duct Dia. In | Air Veloc-ity | Octave Band Center Frequency (Hz) | | | | | |
| | | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| 6 | <500 fpm | 7.4 | 15.2 | 31.3 | 40.4 | 33.5 | 20.7 |
| 8 | <500 fpm | 5.6 | 10.6 | 23.9 | 34 | 22.5 | 17 |
| 12 | <500 fpm | 6.6 | 27.8 | 22.8 | 29.0 | 18.7 | 10.9 |

| Type 1M INSERTION LOSS WITH 90 DEG. ELBOW (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|
| Duct Dia. In | Air Veloc-ity | Octave Band Center Frequency (Hz) | | | | | |
| | | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| 6 | <500 fpm | 4.2 | 310.4 | 28.1 | 40 | 35.4 | 21.9 |
| 8 | <500 fpm | 1.3 | 19 | 34.5 | 35.5 | 25.6 | 16.5 |
| 12 | <500 fpm | 3.2 | 26.6 | 29.1 | 30.5 | 23 | 11.8 |

## PART 3 - EXECUTION

### 3.1 APPLICATION AND INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible".

B. Provide duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel except when another material is specifically specified (Example: aluminum made damper in galvanized duct), stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Volume Dampers:

1. Contractor shall set and lock all dampers in the "Full Open" position prior to balancing work.
2. Mount volume damper quadrants and end bearings so that the fasteners do not limit full damper travel.
3. Provide volume dampers at points on supply, return, and exhaust systems where branches lead from larger ducts as required for air balancing.
4. Install volume dampers as far from the outlet as possible while maintaining at a minimum of two duct widths from branch takeoff. Install at a point where the duct is accessible, if possible, axis of the blade the long dimension.

D. Backdraft Dampers: Install on all exhaust fans or exhaust ducts nearest to outside that are not specified to have automatic dampers and elsewhere as indicated.

E. Duct Silencers: Install rigidly to ducts and provide transition from duct size to silencer connection size. Maintain straight duct upstream and downstream of silencer, as shown on plans, to achieve actual installed pressure drop listed in equipment schedule. Provide support for silencers.

F. Access doors are required, but not typically shown on the drawings.

1. Install duct access doors on side of duct to allow for inspecting, adjusting, and maintaining accessories and terminal units as follows:

a. Upstream of duct mounted coils, smoke detectors, and humidifiers.
b. Adjacent to back draft dampers, providing access to adjust counterbalances.
c. Adjacent to fire or smoke dampers, providing access to reset or reinstall fusible links.
d. Adjacent to automatic control dampers.
e. At turning vanes in return and exhaust ductwork.
**f.** For cleaning operating room supply air duct and kitchen hood exhaust duct, locate access doors at 20-foot intervals and at each change in duct direction.

2. Install the following sizes for duct-mounting, rectangular access doors:

a. One-Hand or Inspection Access: 8 by 5 inches.
b. Two-Hand Access: 12 by 6 inches.
c. Head and Hand Access: 18 by 10 inches.
d. Head and Shoulders Access: 21 by 14 inches.
e. Body Access: 25 by 14 inches.
f. Body Plus Ladder Access: 25 by 17 inches.

3. Install the following sizes for duct-mounting, round access doors:

   a. One-Hand or Inspection Access: 8 inches in diameter.
   b. Two-Hand Access: 10 inches in diameter.
   c. Head and Hand Access: 12 inches in diameter.
   d. Head and Shoulders Access: 18 inches in diameter.
   e. Body Access: 24 inches in diameter.

4. Label access doors according to Division 23, Section 230553, "Identification for HVAC Piping and Equipment."

G. Flexible Connectors:

1. Install immediately adjacent to equipment in ducts associated with fans and motorized equipment supported by vibration isolators.
2. For fans developing static pressures of 5-inch wg and higher, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

H. Flexible Ducts:

1. Refer to SMACNA 2005 Standards, Chapter 3. Ducts shall be continuous, single piece at least 6 and no more than 8 feet long. Ducts shall have at least one, but not more than two, 90° elbows. Centerline radius of bends shall be not less than two duct diameters. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor penetrations fire rated one hour or two hour.
2. Comply with SMACNA support standards and the requirements below.

   a. Provide 2" wide sheet metal or "Saddle-Strap" non-metallic strap hangers maximum four feet on center. More frequent supports may be required to meet sag limitation.
   b. Maximum permissible sag is 1/2" per foot of spacing.
   c. Hangers shall be adequately attached to the building structure. Do not attach hangers to piping, ducts, or conduit.

3.2 INSTALLATION-devices furnished under other sections

A. Motorized Dampers: Install all motorized dampers. Coordinate best location prior to ductwork fabrication and provide damper-manufacturer recommended straight duct length upstream and downstream. Dampers in ductwork and in plenums shall be provided with sheet metal closures all around the dampers frame, including mullions. Seal perimeter of damper frame closures with fire-retardant mastic for airtight closure. Construction and airtightness must be suitable for duct pressure class used. Multiple damper sections shall be bolted together and reinforced at joints with steel angles or channel mullions.

B. Smoke Detectors: Install all smoke detectors furnished by the control contractor or electrical contractor. Review smoke detector submittals and advise manufacturer of anticipated air velocity range. Coordinate best location prior to ductwork fabrication and provide detector-manufacturer recommended straight duct length upstream and downstream. Provide adequate clearance for service and removal.

C. Field-Installed Mixing Damper Installation:

1. Install mixing dampers specified as part of this section or as furnished by others.
2. Provide necessary blank-off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.
3. Assemble multiple sections of dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.
4. Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.
5. Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

D. Air Flow Measuring Devices:

1. Install units specified as part of this section or as furnished by others.
2. Install with minimum straight run distances, upstream and downstream as recommended by the manufacturer. Notify engineer at submittal time if required distances do not appear to be sufficient.

## 3.3 EQUIPMENT AND MATERIALS PROTECTION

A. Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition or return to source of supply for repair or replacement, as determined by the engineer. Protect all equipment and materials from moisture, at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

## 3.4 TESTING

A. Combination Fire Smoke Damper Tests: After installation, all combination fire smoke dampers and all associated controls shall be tested to prove correct control, installation and that damper blades move freely within the confines of the damper frame and do not slip on their shafts. Contractor shall submit a signed statement in O&M Manuals certifying all dampers to be operational.

## 3.5 ADJUSTING

A. Adjust duct accessories for proper settings.

B. Adjust fire and smoke dampers for proper action.

C. Final positioning of manual-volume dampers is specified in Division 23, Section 230593, "Testing, Adjusting, and Balancing for HVAC."

## 3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233300

SECTION 233400 – HVAC FANS

PART 1 - GENERAL

1.1 SUBMITTALS

A. In addition to submitting information to the mechanical engineer, submit fan anchorage and curb drawings and calculations to structural engineer for coordination and approval of roof penetration and roof curb and fan anchorage to the structure.

B. 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.

C. Shop Drawings: For each fan, Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
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.
4. Wiring Diagrams: For power, signal, and control wiring.
5. Operation and maintenance data:

1.2 QUALITY ASSURANCE

A. Single Source Responsibility: Comply with the requirements specified in Division 1.

B. Standardization: Provide air-handling units of the same manufacturer throughout where possible.

C. 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.

## 1.3 DELIVERY, STORAGE, AND HANDLING

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

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

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

## 1.4 WARRANTY

A. Warranty Period: One year from date of Substantial Completion

# PART 2 - PRODUCTS

## 2.1 AIR MOVING EQUIPMENT—GENERAL REQUIREMENTS

A. Criteria:

1. Performance data for all fans shall be determined in accordance with the provisions of AMCA Standard 210.
2. Sound power level ratings of ducted fans shall comply with AMCA Standard 330 and shall be the results of tests made in accordance with AMCA Standard 300.
3. Unit construction shall conform to applicable standards contained in AMCA Standard Handbook Publications and to requirements specified herein.

B. Safety: Safety provisions for power transmission equipment and non-ducted fan inlets and outlets shall include guards and screens, unless other provisions are required, and constructed in accordance with applicable provisions of ANSI/ASME B15.1, the recommendations of the National Safety Council and requirements specified herein. Safety provisions shall not present obstacles to measurement of driver and driven shaft speeds with revolution counter. Installation shall be such that fan vibration isolation provisions are not negated.

C. Nameplate: Provide a metallic, corrosion-resistant, embossed, or stamped nameplate for each fan. Nameplate data shall include selection point capacity conditions, rpm and bhp. Permanently affix in a conspicuous location.

D. Horsepower: Motor brake horsepower input to each proposed fan shall not exceed scheduled brake horsepower.

E. Alignment: All fan wheels shall be statically and dynamically balanced. Fans shall be properly protected during shipment so that bearings are not damaged.

F. Rigging: Field-rigging methods shall not negate balancing. Lifting eyes shall be used. Shafts shall not be bent.

G. Bearings:

1. Bearings shall be heavy-duty self-aligning foot-mounted ball or roller pillow block type. Bearings shall have a certified ANSI/AFBMA L10 minimum rated life of 80,000 hours unless otherwise specified. Bearings shall have dust-tight seals suitable for lubricant pressures encountered. Housings shall be cast iron, unless otherwise specified or approved.
2. Bearings shall be grease lubricated. Lubrication provisions shall be such as to preclude overheating due to excess lubricant or seal blowout due to excess pressure. Grease supply fittings shall be surface ball check type. Provide manual or automatic grease pressure relief fittings as necessary to comply with specified requirements. Bearing and seal construction permitting, relief fittings shall be located on the side opposite to the supply fitting. Relief shall be visible from normal maintenance locations. Lubrication provisions shall include extension tubes where necessary to facilitate safe maintenance while equipment is operating.
3. Permanently sealed pre-lubricated antifriction bearings, which conform to above-specified materials and ANSI/AFBMA L10 life requirements, may be provided for air moving equipment with nameplate horsepower requirements less than 1/2 in lieu of relubricable bearings.

## 2.2 FAN DRIVES AND GUARDS

A. Provide speed controller for direct drive fans.

B. Guards:

1. Guards for each fan drive, except utility set type fans for which the guards are specified with the fan, shall be four-sided guards and shall also cover exposed parts of fan shafts. Size of guards shall also accommodate ultimate capacities shown.
2. Guards shall meet safety standards of AMCA 410, OSHA. Guards shall be provide with 1/2" mesh No. 14-gauge screen in steel angle frame; removable by unbolting sections of the guard for ease of belt replacement; supported on upper isolated base, or from the fan; shall not transmit vibration from fan or motor to the building structure.
3. Size of guards shall be adequate for present fan speed and for future increased fan speeds where two speeds are shown.
4. Guards for roof-mounted fans shall be solid galvanized steel panels, 20-gauge minimum with screen over midsection of top and bottom of belts for inspection and shall be weathertight construction.

## 2.3 MOTORS

A. 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. 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.
2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

3. Provide electronically commutated motors or motors with 70% motor efficiency.

## 2.4 IN-LINE CENTRIFUGAL FANS

A. General: Provide the inline centrifugal fans where shown on the drawings; size, arrangement, and capacity as indicated. Motor horsepower and outlet velocity shall not be exceeded. Fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

B. Basis of design: Greenheck SQ

C. Manufacturer:

1. Greenheck SQ
2. Cook
3. Twin City
4. Car-Mon

D. Performance: Fan performance shall be based on tests conducted in accordance with AMCA Standard Test Code for Air Moving Devices. Fans shall be non-overloading and shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise well beyond the efficiency peak to assure quiet and stable operation under all conditions. Horsepower characteristics shall be truly non-overloading and shall reach a peak in the normal selection area. Fan manufacturer shall provide sound power ratings in the eight octave bands that shall be based on AMCA Standard 300, test set up No. 1. Sound power ratings shall be in decibels referenced 10-12 watts.

E. Wheels:

1. Constructed of aluminum
2. Wheel type to be non-overloading, backward inclined centrifugal wheel
3. Statically and dynamically balanced in accordance to AMCA Standard 204-05
4. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.
5. Single thickness blades are securely riveted or welded to a heavy gauge back plate and wheel cone.

F. Motor and Drive Assembly:

1. Motor enclosures: Totally Enclosed Fan Cooled
2. Electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
3. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
4. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor or integrated variable frequency drive.

5. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
6. Motors can achieve up to 95% efficiency, model and horsepower dependent.

G. Housings:

1. Construction material: Aluminum
2. Square design constructed of heavy gauge galvanized steel, aluminum or painted steel

H. Inlet Cone:

1. Construction material: Aluminum

I. Housing Supports and Drive Frame:

1. Drive Frame is constructed of structural steel with formed flanges.

J. Disconnect Switch:

1. NEMA Rated: 4
2. Positive electrical shut-off
3. Wired from fan motor to junction box

K. Duct Collar:

1. Square Duct Mounting Collar

   a. Inlet and discharge collars provide easy slip fit duct connection
   b. Square design to provide a large discharge area

L. Access Panel:

1. Two sided access panels, permit easy access to all internal components
2. Located perpendicular to the motor mounting panel

M. Options/Accessories:

1. Type: Motorized
2. Galvanized frames with prepunched mounting holes
3. Balanced for minimal resistance to flow

N. Finished:

1. Coating: None

O. Inlet and Outlet Guards:

1. Metal construction to provide protection for non-ducted installations

P. Insulated Housing

1. Thickness: 1 inch
2. For noise reduction and condensation control
3. Constructed of fiberglass liner

Q. Isolation:

1. Type: Direct Mount
2. Sized to match the weight of each fan

R. Motor Cover:

1. Constructed of galvanized steel
2. Covers motor and drives for safety
3. Standard on unit specified with UL and ODP motor enclosures

S. Pressure Probe:

1. 1/4 inch diameter tube in fan venturi that allows hook up to manometer

T. Wiring Pigtail:

1. Direct hook-up to the power supply

## 2.5 CENTRIFUGAL ROOF EXHAUSTERS

A. General: Provide the centrifugal-type roof exhaust fans where shown on the drawings; size and capacity as indicated. Motor horsepower and outlet velocities shall not be exceeded. All fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

B. Basis of design: Greenheck Model G

C. Manufacturer:

1. Greenheck G/GB
2. Cook ACED/ACEB
3. Penn Barry Domex (DX)
4. Car-Mon

D. Construction: The top cap of the roof exhauster shall be made of heavy gauge spun aluminum. The top cap shall be designed for easy access for scheduled maintenance or repairs. The unit base shall be heavy gauge spun aluminum of one-piece construction to insure weathertight conditions. All exterior parts including wheel, wheel hub, supporting posts and all outside fasteners shall be of aluminum or non-ferrous construction.

E. Fan Wheel:

1. Constructed of aluminum
2. Non-overloading, backward inclined centrifugal
3. Statically and dynamically balanced in accordance to AMCA Standard 204-05
4. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.

F. Motor and Drive Assembly:

1. Electronically Commutated Motor

   a. Motor enclosures: Open type
   b. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
   c. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
   d. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.
   e. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
   f. Motor shall be a minimum of 85% efficient at all speeds.

G. Housing:

1. Motor cover, shroud, curb cap, and lower windband shall be constructed of heavy gauge aluminum
2. Shroud shall have an integral rolled bead for extra strength
3. Shroud shall be drawn from a disc and direct air downward
4. Lower windband shall have a formed edge for added strength
5. Motor cover shall be drawn from a disc
6. All housing components shall have final thicknesses equal to or greater then preformed thickness.
7. Curb cap shall have pre-punched mounting holes to ensure correct attachment
8. Rigid internal support structure
9. Leak proof

H. Housing Supports and Drive Frame:

1. Drive frame assemblies shall be constructed of heavy gauge steel and mounted on vibration isolators.

I. Vibration Isolation:

1. Rubber isolators
2. Sized to match the weight of each fan

J. Disconnect Switches:

1. NEMA rated: 4
2. Positive electrical shut-off
3. Wired from fan motor to junction box installed within motor compartment

K. Options/Accessories:

1. Birdscreen:

a. Material Type: Galvanized
b. Protects fan discharge

L. Roof Curbs:

1. Types: GPI
2. Mounted onto roof with fan
3. Material: Aluminum
4. Insulation thickness: No insulation
5. Flashing Flange: 2 inch
6. Coating Type: Hi-Pro Polyester
7. Curb Seal: Rubber seal between the fan and the roof curb

M. Dampers:

1. Type: Motorized
2. Prevents outside air from entering back into the building when fan is off
3. Balanced for minimal resistance to flow
4. Galvanized frames with prepunched mounting holes

N. Finishes:

1. Types: Hi-Pro Polyester

O. Hinge Kit:

1. Aluminum hinges
2. Allows the fan to tilt away for access to wheel and ductwork for inspection and cleaning

P. Hinge Base:

1. Aluminum hinges
2. Hinges and restraint cables are mounted to a base (sleeve)
3. Allows the fan to tilt away for access to wheel and ductwork for inspection and cleaning

Q. Pressure Probe:

1. ¼ inch diameter tube in the fan venturi that allows hook up to manometer

R. Tie-Down Points:

1. Four heavy gauge aluminum brackets to secure the fan in heavy wind applications

## 2.6 FUME EXHAUST FAN-HIGH PLUME LABORATORY EXHAUST

A. General: Provide the roof mounted fume exhaust fans where shown on the drawings; size and capacity as indicated. Motor horsepowers and outlet velocities shall not be exceeded. All fans shall be AMCA Certified for both Air and Sound Performance. Only AMCA Certified fans are acceptable.

1. Base fan performance at standard conditions (density 0.075 Lb. /ft3 ).
2. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.
3. Each fan shall be direct drive.
4. Each fan to be equipped with 316 stainless steel lifting lugs for corrosion resistance.
5. Fasteners exposed to corrosive exhaust shall be stainless steel.
6. Fan assembly shall be designed for a minimum of 125 MPH wind loading, without the use of guy wires.

B. Basis of design: Greenheck Vektor-H

C. Manufacturers:

1. Greenheck
2. Cook
3. Twin City

D. Fan Housing and Outlet: Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.

1. Fan housing shall be welded steel and meet corrosion resistant coating as described in this specification. No uncoated metal fan parts shall be acceptable.
2. Load bearing or structural fan components that are fabricated of polypropylene or fiberglass that have lower mechanical properties than steel, have rough interior surfaces in which corrosive, hazardous compounds can collect, and/or which chalk and structurally degrade due to the UV component of the sunlight shall not be acceptable.
3. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM. Discharge nozzles shall be steel with corrosion resistant coating or chemical resistant medium density polyethylene with UV inhibitors to prevent chalking and have smooth interior surfaces. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted.
4. Provide housing drain for removal of rain and condensation.
5. Motor compartment shall be sealed from the contaminated airstream and have integral cooling vents to fan exterior housing to prevent heat build-up.
6. Housing shall have a bolted and gasketed access panel allowing for inspection of impeller.
7. Impeller, inlet cone and motor shall be removable in a single cartridge from the exterior of the fan housing without removal of the fan housing from plenum or roof curb.

E. Fan Impeller: shall be centrifugal, backward curved, with laminar blade geometry and non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204.

1. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant) and meet corrosion resistant coating as described in this specification.
2. Aluminum centrifugal impellers shall be coated with Hi Pro polyester resin

F. Protective Coatings: All steel fan and system components (fan, nozzle, windband and plenum) shall receive factory-applied finish for resistance to chemicals and corrosive agents.

1. All parts shall be cleaned and chemically prepared for coating using a multistage wash system which includes acid pickling to remove oxide.
2. The first powder coat shall be a partial cure epoxy primer. The second powder coat of polyester resin shall be electrostatically applied and then be cured simultaneously at a uniform temperature of 400°F.
3. The coating system shall not be less than a total thickness of 6 mils, shall not be affected by the UV component of sunlight (does not chalk), and have superior corrosion resistance to acid, alkali, and solvents. Coating system shall exceed 4000 hour ASTM B117 Salt Spray Resistance.

G. Bypass Air Plenum: If necessary to achieve fan nozzle outlet velocity or fan side inlet condition, a bypass air plenum shall be provided. The plenum shall be equipped with a bypass air damper and intake air hood with bird screen for introducing outside air at roof level upstream of the fan.

1. The plenum shall be constructed of fully welded steel, meet corrosion resistant coating as described in this specification, and mount on roof curb. Plenums that are fabricated of plastics or resins that are combustible and have mechanical properties less than steel shall not be acceptable.
2. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer, as described in this specification. Fan designs that use inlet flexible connectors that can leak causing loss of lab exhaust shall not be accepted.
3. Bypass air dampers shall be opposed-blade design, and coated with up to 4 mils of Hi-Pro polyester resin, electrostatically applied and baked.
4. Fan isolation damper of parallel blade design, two position actuated, fabricated of steel or aluminum and coated with minimum 4 mils of Hi-Pro polyester resin, electrostatically applied and baked, shall be provided.
5. Blower / Plenum vibration isolation shall be limited to neoprene / cork vibration pads.

H. Curb: Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the drawings.

1. Curb shall be fabricated of a minimum of 14 gauge of corrosion resistant coated steel and structurally reinforced.
2. Curbs shall be insulated.
3. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.

I. Fan Motors and Disconnect: Motors shall be premium efficiency, standard NEMA frame, 1800 or 3600 RPM, Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor on line (sinewave) frequency. Motor shall be labeled for use with a VFD with 10:1 VT and 1.0 service factor.

1. Motor bearings shall be sealed for life and require no lubrication maintenance.
2. Motor shall be equipped with internal shaft grounding ring protect motor bearings from the shaft voltages.
3. Motor bearings shall be sized for an L-10 life of no less than 100,000 hours in vertical shaft down application.
4. A factory-mounted NEMA 3R disconnect switch shall be provided for each fan.

## 2.7 AIR CURTAINS

A. Basis-Of-Design: Berner

B. Manufacturers:

1. Berner
2. Mars
3. Powered Aire
4. Schwank

C. Construction: Provide factory-assembled units of sufficient structural strength to be supported from ends without intermediate support. Ship units completely assembled.

D. Cabinet:

1. Material and Finish: Aluminized steel cabinet with stainless steel riveted construction and white powder coated finish.
2. Mounting: Provide for wall mounting.
3. Service Access: Removable screen and removable bottom access panel.

E. Motors: 1/5-HP, 1680 rpm, single phase, 2-speed, ODP, direct drive, resilient mounted, continuous duty, with internal thermal-overload protection and permanently lubricated sealed ball bearings.

F. Fans: Balanced forward curved cross flow, tangential type, made of aluminum with flexible hubs and mounted in matched fan scrolls constructed of material used in constructing cabinet.

G. Discharge Nozzles:

1. Provide uniform velocity across width of air curtain.
2. Aperture: 2.375 in (6 cm) slot by width of air curtain.

H. Vanes: 1.5 in (3.8 cm) minimum height; constructed of airfoil-shaped aluminum extrusions; adjustable plus or minus 20 degrees to deflect airflow.

I. Inlet:

1. Location: Front.
2. Screen: Perforated pattern constructed of the same material and finish used for the cabinet.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine fans before installation. Reject fans that are wet, moisture damaged, or mold damaged.

3.2 INSTALLATION-FANS

A. General: The installation of the fans shall conform to local codes and ordinances, NFPA 90A, and SMACNA. Mounting and supporting of all equipment including accessories and appurtenances shall be provided, including but not limited to structural supports, hangers, vibration isolators, stands, clamps, and brackets.

B. Installation of Equipment: Installation shall conform to equipment manufacturer's recommendations, unless otherwise indicated. Equipment shall be installed, leveled and located so that working clearance is available under overhead lines and so that working space is available for all necessary servicing such as shaft removal, replacing or adjusting drives and motors, lubrication, and access to automatic controls.

3.3 ELECTRICAL WORK

A. General: Electric motor-driven equipment specified in this section shall be provided complete with motors and controls. Electric equipment and wiring shall comply with requirements of NFPA 70 and Division 26, "Electrical Work".

B. Starters: Motor starters and disconnects, unless otherwise specified or indicated shall be furnished and installed by Division 26 Contractor.

3.4 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section 260553, "Identification for Electrical Systems."

3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233400

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes the following:

1. Single duct air control valves.
2. Electric resistance duct heaters.
3. Tracking Return/Exhaust air control valves.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.

1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
2. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Reflected ceiling 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. Ceiling suspension assembly members.
2. Method of attaching hangers to building structure.
3. Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
4. Primary service access opening.

D. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:

1. Instructions for resetting minimum and maximum air volumes.
2. Instructions for adjusting software set points.

## 1.4 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

## 1.5 COORDINATION

A. Coordinate layout and installation of air terminal units and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

# PART 2 - PRODUCTS

## 2.1 VENTURI VALVE (VV)

A. Approved Manufacturers:

1. Antec Controls
2. Phoenix Controls
3. Accutrol, LLC

B. General:

1. The airflow control device shall be a mechanically pressure independent Venturi Valve, a low pressure device capable of operating at static pressures of 0.3 to 3 inches water gauge.

C. Performance Requirements:

1. The Venturi Valve assembly shall be pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change or quantity of airflow controllers on a manifold system.
2. The airflow control device shall maintain a controlled accuracy within plus or minus five percent of signal over the airflow range.
3. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.

D. Construction:

1. The airflow control device shall be constructed as:

   a. Non-Corrosive: The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be 14-gauge aluminum (valve body) and 16-gauge aluminum (valve cone) construction. The center shaft shall be PTFE Teflon coated 316 stainless steel. The center shaft support brackets shall be 316 stainless steel. The pivot arm and internal mounting link shall be 316 stainless steel. The pressure independent springs shall be spring-grade stainless steel. All shaft bearing surfaces shall be Teflon.
   b. Supply valves shall be insulated with ¾ inch flexible closed-cell polyethylene insulation with a flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E84.

2. The airflow control device shall ship with all required components including electric duct heaters matched for performance as required.
3. Airflow control devices using airflow sensing technology to measure live airflow readings, including cross-flow sensors, vortex shedding sensors, and differential static pressure sensors, shall not be acceptable.

E. Shut-Off:

1. The airflow control device shall be constructed as:

   a. Standard Shut-off: The airflow control device shall incorporate a lip rolled into the valve body for the cone assembly to seat against. Shut-off shall be metal-to-metal contact, achieved at a minimum actuator signal. Shut-off performance shall be tested in accordance with ASHRAE 130, with an inlet pressure of up to 3in.w.c.

F. Actuation:

1. For electrically actuated VAV operation for tracking pairs (supply and exhaust valves), and two-position valves in laboratory spaces without fume hoods, a low-speed electric actuator shall be used to modulate the airflow over the range of the specific valve size.
2. A UL or CSA listed electronic actuator shall be factory mounted to the valve. The actuator shall have sufficient torque to modulate the airflow against the maximum duct static pressure (within product specifications).
3. For electrically actuated VAV operation for fume hood laboratories (includes all supply, general exhaust, and fume hood valves in the space), a high-speed electronic actuator shall be factory mounted to the valve.
4. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. This position shall be maintained until power is restored:

   a. Supply/make-up air valves:

      1) Fail to last airflow position.

   b. General exhaust air valves:

      1) Fail to open position.

5. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications).
6. Constant volume valves shall not be equipped with any electronic control actuator requirement.

    a. Constant volume valves shall:

        1) Maintain a constant volume, pressure independent, manually adjustable, volume airflow setpoint
        2) Be factory calibrated for the desired constant volume airflow rate
        3) Be capable of field adjustment for future changes of desired airflow rate

    b. Constant volume valves shall be:

        1) Provided with a valve pressure switch, capable of communicating a dry contact signal when the valve operating pressure drop falls below a threshold

G. Certification:

1. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NIST traceable air stations and instrumentation having a combined accuracy of no more than plus or minus one percent of signal over the entire range of measurement. Airflow control devices shall be further calibrated and their accuracy verified to plus or minus five percent of signal at a minimum of 48 different airflows across the full operating range of the device.
2. Each airflow control device shall be marked with device-specific factory calibration data, a unique serial number and a tag number. At a minimum this serial number shall be traceable to, the model number, characterization information (for electronic devices), and quality control documentation. All information shall be stored by the manufacturer for use with as-built documentation.

H. Accessories:

1. Electric Heating Coil – VVEC:

    a. The electric heating coil shall be ETL listed to UL 1996 and CSA236, and provided by the Venturi Valve manufacturer.
    b. The electric coil casing shall be constructed from a minimum 20 gauge, 0.038 inch galvanized steel.
    c. The heating elements shall be open wire nickel chrome construction, supported by ceramic insulators.
    d. The integral control panel shall be a NEMA 250, Type 1 enclosure with hinged access door for access to all controls and safety devices.
    e. The electric coils shall be provided with a primary automatic reset thermal cutout, a secondary manual reset thermal cutout, and a differential pressure airflow switch for proof of airflow.
    f. The electric coil shall be provided with a silicon controlled rectifier (SCR) controller with Analog Control 0-10 VDC.
    g. The electric coil housing shall be lined with 3/4 inch fiber-free insulation.

h. The electric coil shall be provided with a non-fused door interlocking disconnect switch.
i. The electric coil shall be provided with main-line fusing.

## 2.2 SOURCE QUALITY CONTROL

A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, and ARI certification seal.

B. Verification of Performance: Rate air terminal units according to ARI 880.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.

B. Electric isolation shall be provided between dissimilar metals for the purpose of minimizing galvanic corrosion.

C. Each terminal unit shall be identified in accordance with the identification system indicated on the schedule or drawings with labels complying with Division 23 Section “Identification for HVAC Piping and Equipment”. Identification on unit shall be readable from the floor through the primary service access opening.

## 3.2 CONNECTIONS

A. Connect ducts to air terminal units according to Division 23 Section "Metal Ducts and Casings."

B. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."

C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

D. 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.

## 3.3 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. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.

C. Remove and replace malfunctioning units and retest as specified above.

## 3.4 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup check(s) according to manufacturer's written instructions and do the following:

a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
b. Verify that controls and control enclosure are accessible.
c. Verify that control connections are complete.
d. Verify that nameplate and identification tag are visible.
e. Verify that controls respond to inputs as specified.

## 3.5 DEMONSTRATION

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

## 3.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233600

SECTION 233700 – AIR INLETS AND OUTLETS

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 ceiling and wall-mounted diffusers, registers, grilles, louvers, and gravity ventilators.

B. Related Sections include the following:

1. Division 23 Section "Air Duct Accessories" for volume-control dampers not integral to diffusers, registers, and grilles.

1.3 SUBMITTALS

A. Product Data: For each product indicated, include the following:

1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
2. Diffuser, Register, and Grille Schedule: Indicate Drawing designation, room location, quantity, model number, size, and accessories furnished.

1.4 SOURCE QUALITY CONTROL

A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

PART 2 - PRODUCTS

2.1 DIFFUSERS

A. General: Diffusers shall be sizes and mounting types shown on drawings and as scheduled. All diffusers shall be provided with earthquake tabs where required by code. Whether required by code or not, all diffusers shall be provided with earthquake tabs if the weight of the assembly (including all accessories and the plenum above) is more than fifteen (15) pounds unless the assembly is rigidly attached to, and can be fully supported from, a fully-supported sheet-metal duct or plenum.

B. Square Face Modular Core Adjustable Diffusers:

1. 1, 2, 3, or 4-way adjustable discharge pattern, steel construction, square or rectangular neck.
2. Back pan shall be one-piece stamped heavy gauge steel. Diffuser neck shall have 1-inch minimum depth to facilitate duct connection.
3. Diffuser core shall consist of fixed louver directional modules, which can be easily repositioned without tools in the field for 1, 2, 3, or 4-way discharge. Each module shall be easily removable to adjust the dampers in neck of the diffuser.
4. Diffuser will be provided with filter frame. Contractor to field install mesh 80 screen on diffuser.
5. Diffuser will be supplied with a steel or aluminum volume control damper. Material shall match diffuser.
6. Manufacturers:

    a. Price Model SCD
    b. Titus
    c. Nailor

## 2.2 GRILLES AND REGISTERS

A. General: Grilles and registers shall be sizes and mounting types shown on drawings and as scheduled.

B. Steel Supply Grilles:

1. Grilles shall be double deflection type unless indicated otherwise on the drawings. Exposed deflection blades shall be horizontal when viewed from the room (typically, the first dimension indicated is the horizontal dimension).
2. Grilles shall be steel construction with a 1-1/4" wide border on all sides, having a minimum thickness of 20-gauge. Screw holes shall be countersunk. Corners shall be welded with full penetration resistance welds with a reinforcing steel patch for extra strength.
3. Deflection blades shall be constructed of heavy-duty aluminum spaced on 3/4" centers. Blades shall extend completely through the side frame on each side to provide stability throughout the complete CFM operating range of the grille. Blades shall be individually adjustable without loosening or rattling and shall be held in place with tension wire.
4. Grilles will be provided with filter frame. Contractor to field install mesh 80 screen on grille.
5. Grille will be supplied with a steel volume control damper.
6. Manufacturers:

    a. Price Model 510
    b. Titus
    c. Nailor

C. Wall-mounted Steel Return and Exhaust Grilles:

1. Grilles shall have fixed deflection blades**,** which shall be horizontal when viewed from the room (typically, the first dimension indicated is the horizontal dimension).
2. Grilles shall be steel construction with a 1-1/4" wide border on all sides, having a minimum thickness of 20-gauge. Screw holes shall be countersunk. Corners shall be welded with full penetration resistance welds with a reinforcing steel patch for extra strength.
3. Blades shall have a formed curvature, laboratory tested and certified for performance. Blades shall be 20-gauge minimum construction. Fixed deflection angle shall be 35°.
4. Where indicated, integral opposed blade dampers shall be provided, constructed of heavy gauge steel. Damper shall be operable from the face of the grille.
5. Borders of grilles shall be suitable for installation surface and materials. Border type shall be surface mount or otherwise as indicated or required for the associated surface. Verify border requirements.
6. Grilles will be provided with filter frame. Contractor to field install mesh 80 screen on grille.
7. Manufacturers:

    a. Price Model 530/630
    b. Titus
    c. Anemostat
    d. Carnes
    e. Krueger
    f. Metalaire/Greenheck.
    g. Nailor

D. Ceiling-mounted Steel Return and Exhaust Grilles:

1. Except as noted below, grilles shall be the same as specified for wall-mounted grilles.
2. Grilles in lay-in ceilings shall not have screw holes in the border.
3. Grilles shall have fixed deflection blades, which shall be perpendicular to the line of sight when viewed from the center of the room.
4. Borders of grilles shall be suitable for installation surface and materials. Border type shall be surface mount, snap-in, lay-in, spline, or channel frame type as indicated or required for the associated surface. Verify border requirements.
5. Grilles will be provided with filter frame. Contractor to field install mesh 80 screen on grille.
6. Manufacturers:

    a. Price Model 530/630
    b. Titus
    c. Anemostat
    d. Carnes
    e. Krueger
    f. Metalaire/Greenheck.
    g. Nailor

## 2.3 COMBINATION LOUVERS

A. General: Provide louvers at locations shown on the drawings, size and type as indicated on mechanical equipment schedules.

B. Manufacturers:

1. Ruskin
2. Greenheck

C. Construction

1. Louver frame shall be 6 inch deep channel style with 0.125 inch extruded aluminum wall thickness.
2. Stationary front blades shall be drainable style located on approximately 6.5 inch centers and 45 degree angles with 0.081 inch extruded aluminum wall thickness.
3. Operable rear blades shall be center pivot style with 0.081 inch extruded aluminum wall thickness.
4. Jamb seals shall be compressible style stainless steel. Blade seals shall be dual-durometer extruded vinyl style.
5. Blade linkage shall be out of airstream and concealed within frame. Blade axles shall be 0.5 inch diagonal zinc plated steel. Axle bearings shall be synthetic sleeve type

D. Performance

1. Louver performance shall be certified in accordance with the AMCA 511 Certified Ratings Program when tested in accordance with AMCA 500-L Air Performance and Water Penetration.
2. Airflow resistance at 1000 feet per minute free area intake velocity shall not be greater than 0.125 inch water gauge pressure drop. Airflow resistance at 1000 feet per minute free area exhaust velocity shall not be greater than 0.161 inch water gauge pressure drop.
3. Beginning point of water penetration shall not be less than 1020 feet per minute free area intake velocity.
4. Louvers shall be designed and manufactured to withstand a minimum 25 pound per square foot wind load.

E. Birdscreen:

1. Constructed of ½ inch Aluminum mesh
2. Mounted horizontally across the intake area of the hood

F. Options/Accessories:

1. Provide 24V electric actuator to interlink louver with associated exhaust fan.
2. Provide Kynar paint finish, color shall be determined by owner prior to ordering louver.
3. Provide 18 x18 mesh by .009 inch diameter stainless steel wire insect screen.

## 2.4 GRAVITY VENTILATORS

A. General: Provide roof-mounted gravity relief ventilators at locations shown on the drawings, size as indicated, each with backdraft damper.

B. Manufacturers:

1. Penn Barry "Airette"
2. Cook
3. Greenheck
4. Nailor

C. Hood

1. Constructed of aluminum
2. Internal structure is constructed of galvanized steel

D. Birdscreen:

1. Constructed of ½ inch Aluminum mesh
2. Mounted horizontally across the intake area of the hood

E. Housing:

1. Curb Cap type: No Hinged
2. Constructed of aluminum, includes windband and curb cap. Galvanized material is not acceptable
3. Windband to be one piece spun aluminum construction and maintain original material thickness throughout the housing.
4. Windband to include an integral rolled bead for strength
5. Curb cap to have integral deep spun inlet venturi and prepunched mounting holes to ensure correct attachment to roof.

F. Options/Accessories:

1. Curb Seal:

   a. Rubber seal between fan and the roof curb

2. Roof Curbs:

   a. Type: GPI
   b. Mounted onto roof with fan
   c. Material: Aluminum
   d. Insulation thickness: No insulation
   e. Flashing Flange: 2 inch

G. Dampers:

1. Type: Motorized
2. Prevents outside air from entering back into the building when fan is off
3. Balanced for minimal resistance to flow

4. Galvanized frames with prepunched mounting holes

H. Finishes:

1. Type: Hi-Pro Polyester

I. Flashing Flange:

1. Constructed of aluminum
2. Pre-punched holes for installation without a roof curb

J. Hood Insulation:

1. Lined with 1 inch fiberglass insulation to prevent condensation and sound levels

K. Insect Screen:

1. Constructed of fine mesh aluminum
2. Fitted to the top of the throat and prevents entry of insects

L. Tie-Down Points:

1. Four aluminum brackets located on windband secures fan in heavy wind applications

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.

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

### 3.2 EQUIPMENT AND MATERIALS PROTECTION:

A. Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition, or return to source of supply for repair or replacement, as determined by A/E. Protect all equipment and materials from moisture at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

### 3.3 INSTALLATION

A. Diffuser Connection: Provide a minimum of 12” of straight (vertical) duct above ceiling diffusers or furnish an prior approved plenum above diffusers.

B. Install diffusers, registers, and grilles level and plumb in accordance with the details and notes indicated and the recommendations and printed instructions of the manufacturer for each item.

C. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practicable. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.

D. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

E. Exhaust Grilles in Rooms with Showers: As specified for exhaust grilles in general, except all aluminum construction.

F. Frames and Borders:

1. Diffusers and grilles shall have border or margins for tight fit to ceilings for optimum ceiling appearance, designed to cover ceiling openings and minimize dirt development on ceiling. All diffusers and grilles shall be provided with duct rings secured to diffuser or grille outer shell with concealed fasteners.
2. Square Diffusers and Grilles for Exposed "Tee" Grid Ceilings: Square diffusers and grilles that fit well within the framing grid shall be flanged. Where dimension corresponds to the grid dimension, diffuser or grille shall be the same pattern as specified above except margins shall be 5/8" wide with outside dimensions for "lay-in" installation in the standard tee spacing required by the architectural drawings.

G. Ceiling Grille Orientation: Return and exhaust grilles and registers shall be installed in ceilings such that the blade angle blocks line-of-sight into the duct from the center of the room. If the best orientation still allows the ductwork interior to be seen through the grille from any point in the room that is more than 3 feet from a wall, the visible portion of the interior shall be painted with flat-black paint.

H. Structural Supports: When very large diffusers are installed, sufficient structural support shall be provided to prevent sagging or distortion of the unit. Provide seismic restraints to prevent diffuser from being dislodged from the ceiling.

I. Where diffuser and ceiling grille assemblies that weigh more than 15 pounds (and less when required by code), they shall be fully supported independent of a lay-in ceiling grid.

## 3.4 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing. Set throw direction at all linear diffusers and modular core diffusers. In general, air shall be directed away from adjacent walls, unless indicated otherwise on the drawings. Request engineer direction if proper arrangement is not readily apparent.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 233700

SECTION 234100 - PARTICULATE AIR FILTRATION

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 factory-fabricated air-filter devices and media used to remove particulate matter from air for HVAC applications.

1.3 DEFINITIONS

A. DOP: Dioctyl phthalate or bis-(2-ethylhexyl) phthalate.

B. HEPA: High-efficiency particulate air.

C. ULPA: Ultra low penetration air.

D. MERV: Minimum Efficiency Reporting Value

1.4 SUBMITTALS

A. Product Data: Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

B. Shop Drawings: Include plans, elevations, sections, and details to illustrate component assemblies and attachments.

1. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
2. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
3. Retain subparagraph below if equipment includes wiring.
4. Wiring Diagrams: Power, signal, and control wiring.

C. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

## 1.5 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air filters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."

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 ARI 850.

D. Comply with ASHRAE 52.1 and ASHRAE 52.2 for method of testing and rating air-filter units.

E. Comply with NFPA 70 for installing electrical components.

F. Comply with NFPA 90A and NFPA 90B.

## 1.6 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

## 1.7 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. Provide one complete set of filters for each filter bank. If system includes prefilters, provide only prefilters.

# PART 2 - PRODUCTS

## 2.1 AIR FILTERS

A. Pleated Panel Air Filters (Pre-Filters):

1. Manufacturers:

a. Camfil Farr 30/30
b. Flanders Airpure
c. American Air Filter

2. General: Provide the air filters, complete with filter cartridges and holding frames. Each filter shall be provided with an identification plate, visibly mounted after construction showing serial number, model number and all other data necessary for ordering renewable media.

3. Enclosing Frame: Rigid, heavy-duty beverage board with diagonal support members bonded to the air entering and an exit side of each pleat, to ensure pleat stability. The inside periphery of the enclosing frame shall be bonded to the filter pack as to eliminate air bypass.
4. Ratings:

    a. Filter shall be rated MERV 8-A per ASHRAE 52.2.
    b. The filter media shall have an average efficiency of 25% to 30% on ASHRAE Test Standard 52.1-92.
    c. Media shall have an average synthetic dust arrestance of 90% Plus in accordance with ASHRAE Test Standard 52.1-92.
    d. Filter shall have a Minimum Efficiency Reporting Value of MERV 8 when evaluated according to ASHRAE Standard 52.2 and a MERV-A rating of 8 when tested per Appendix J of the same standard.
    e. Filters shall be UL Class 2.

5. Effective Filter Media:

    a. 2" Thick: The effective filter media for the 2" thick filters shall be not less than 3.3 sq. ft. of media per 1.0 sq. ft. of filter face area and shall contain not less than 10 pleats per linear foot. Initial resistance at 500 fpm approach velocity shall not exceed 0.28 in. w.g.

B. High Performance Rigid Type Air Filters (Final Filters):

1. General: Provide the air filters, complete with filter cartridges and holding frames. Filter banks shall be field erected, size and arrangement as shown on the drawings. Each filter shall be provided with an identification plate, visibly mounted after construction showing serial number, model number and all other data necessary for ordering renewable media.
2. Filter Media: Filters shall be high-density microfine glass fiber media, deep pleated, totally rigid, and totally disposable type.
3. Media Support: Media support shall consist of a welded wire grid with an effective open area of not less than 96%. Grid shall be bonded to filter media for rigidity and shall be designed to support the media both vertically and horizontally.
4. Filters Contour Stabilizers: Contour stabilizers shall be permanently installed on both the air entering and air exit sides of the filter media pack to ensure that the tapered radial pleat configuration is maintained throughout the life of the filter. The filter shall be capable of withstanding 10 in. w.g. pressure drop without noticeable distortion of the media pack.
5. Enclosing Frame: Frame enclosing the air filter shall be constructed of galvanized steel, designed so that a rigid and durable enclosure for the filter pack is affected. The filter pack periphery shall be continuously bonded to the inside of the enclosing frame to prevent air bypass. The enclosing frame shall be equipped with protective diagonal supports on both entering and exit side of the filter.

    a. High Efficiency Filters **(**85%**):**

        1) Filters shall be rated MERV 13 per ASHRAE 52.2 and a MERV-A rating of 13 when tested per Appendix J of the same standard.

2) Filters shall be 85% efficiency per ASHRAE 52.1-92 using atmospheric dust.
3) The initial pressure drop of each high efficiency clean filter cartridge when operated at 500 fpm shall not exceed 0.49 in. w.g.; final pressure drop shall not exceed 1.5 in. w.g. Filter media area shall be not less than 58 sq. ft.
4) Filter shall be UL Class 2.
5) Manufacturers:

a) Camfil AQ13
b) Flanders
c) American Air Filter

C. Holding Frames: Holding frames shall be factory fabricated of 16-gauge galvanized steel equipped with gaskets and four heavy-duty positive-sealing fasteners. Each fastener shall be capable of withstanding 25 lbs. pressure without deflection and shall be capable of being attached or removed without the use of tools.

1. Manufacturers:

a. Farr Company Type 8
b. Flanders
c. Camfil
d. Koch

D. Filter Housings—Side Access Type: Housings shall be factory fabricated and assembled; not less than 16 gauge galvanized steel construction; two access doors of adequate size for filter removal; extruded aluminum tracks and individual universal holding frames designed to accommodate the filters specified herein.

1. Manufacturer:

a. Farr Company Model 3P "Universal Glide/Pack"
b. Flanders
c. American Air Filter.
d. Camfil
e. Koch

E. Filter Differential Pressure Gauges:

1. Inclined Type Draft Gauge: Provide solid acrylic plastic draft gauge across each filter bank with three-way valve on the sensing connections for checking liquid level and filling. Each gauge shall be equipped with two 5' lengths of 1/4" tubing, two static pressure taps, toggle bolt mounting assemblies, and red gauge oil: scale range 0.20-0-3.0 in. w.g.

a. Manufacturer: Dwyer “Durablock” Model 200 series AF.

2. Magnehelic Type Gauge: Provide flush mounted differential pressure gauge to measure filter resistance across each filter bank. Gauge shall be the diaphragm-actuated dial type, 4-3/4" O.D. with white dial, black figures and graduations and pointer zero adjustment.

Gauges shall include all mounting and connection fittings. Gauges shall be within the range of 0-2.0 in. wg. in 0.05 minor divisions.

a. Manufacturer: Dwyer "Magnehelic" Model 2000 series.

## 2.2 SPECIALIZED AIR FILTERS

### A. High Efficiency HEPA Filters

1. Air filters shall be absolute grade HEPA filters consisting of pleated media packs assembled in a V-bank configuration, polyurethane sealant, anodized aluminum enclosure and seamless fluid sealing gasket. Sizes shall be as noted on enclosed drawings or other supporting materials.
2. Construction: Filter media shall be microfiber glass formed into mini-pleat pleat-in-pleat V-bank design. The media packs shall be potted into the enclosing frame with fire retardant polyurethane sealant. An enclosing frame of anodized extruded aluminum shall form a rugged and durable enclosure. A seamless sealing gasket shall be included on the downstream side of the filter to form a positive seal upon installation.
3. Performance: Filter efficiency at 0.3 micron shall be 99.99% when evaluated according to the IEST Recommended Practice for applicable type. Each filter shall be labeled as to tested performance. Initial resistance target shall not exceed 1.0” w.g. at rated airflow.
4. Supporting Data: The filter shall be labeled as to tested efficiency, rated/tested cfm, pressure drop and shall be serialized for identification. The manufacturer shall supply a Certificate of Conformance for each HEPA filter supplied to the facility.
5. Filter must be listed as UL 586 and UL 900 per Underwriters Laboratories. Manufacturer shall provide evidence of facility certification to ISO 9001:2000.

### B. Bag-in/Bag-out HEPA Air Filter Housing

1. Construction

   a. The housing shall be bag-in/bag-out, gasket seal housing and shall be manufactured from 14 Ga. & 11 Ga. T-304 or T-316 stainless steel (unpainted).
   b. The housing shall be adequately reinforced to withstand a negative or positive pressure of 15" water gage.
   c. The housing shall be side-servicing for filter installation and change-out. Housing design and filter arrangement shall allow air to enter and exit housings without changing direction.
   d. The housing shall accommodate standard size gasket seal filters which do not require any special attachments to function properly within the housing. Seal is effected when filter gasket is compressed onto sealing surface.

e. Welding: All "pressure retaining" weld joints and seams shall be continuously welded; weld joints and seams requiring only intermittent welds by design shall not be continuously welded. As a minimum, all weld joints and seams shall be wire brushed and/or buffed to remove heat discoloration, all burrs, and sharp edges. All weld joints and seams that are a portion of any gasket setting surface (i.e., duct connecting flanges) shall be ground smooth and flush with adjacent base metals. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. All production welds shall be visually inspected per the workmanship acceptance criteria described in sections 5 & 6 of ANSI/AWS D9.1-1990, "Specification for Welding of Sheet Metal".

f. Bagging Ring: The housing shall have a bagging ring flange around each filter access port, that is sealed by a gasketed filter access door. The filter access door gasket shall be neoprene and shall be manually replaceable. The bagging ring flange shall have two (2) continuous formed raised ridges to secure the PVC change-out bag. The bagging ring flange is hemmed on the outer edge to prevent the change-out bag from tearing. One (1) PVC change-out bag shall be furnished with each filter access port. Change-out bags shall be 8 mil. thick with a yellow translucent, non-sticking, matte textured finish and have a 1/4" dia. elastic shock cord hemmed into the opening of the bag so when stretched around the bagging ring flange, it is a secure fit. Bag shall include three (3) glove ports built into the bag to assist in filter change-out. One (1) security strap shall be furnished per filter access port, to prevent the bag from sliding off the bagging ring flange during the filter change process. All change-out operations shall be within the bag.

g. Hardware: All hardware on the housing and mechanical components of the filter sealing mechanism are 300 series stainless steel except for the access door knobs which are cast aluminum (to prevent galling of threads) and brass locking tray nuts.

h. Locking Tray: The clamping mechanism shall be operated by means of a wrench from outside the housing front. The mechanism shall include independent pressure bars with compression springs that exert a minimum sealing force of 1,400 lbs. per filter, applied as an even, uniform load along at least 80% of the top and bottom of each filter frame.

i. Removal Rod: Multi-wide housing shall be equipped with a filter removal rod to pull the filters to the change-out position. The removal rod shall operate from inside the filter change out bag.

j. Quality assurance and factory testing: The filter housing shall be manufactured under a quality assurance program that addresses the requirements of ANSI/ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities". Housing shall be tested for filter fit, operation of the filter clamping mechanism and leak tightness before leaving the factory. Both the filter sealing surface and the complete assembly pressure boundary shall be leak tested by the "pressure decay method", in accordance with ANSI/ASME N510-1989 (reaffirmed in 1995), "Testing of Nuclear Air-Cleaning Systems", paragraphs 6 & 7 and have a maximum leak rate of 0.0005 CFM per cubic foot of housing volume at 15" water gage. Test duration shall be 5 minutes with pressure readings recorded at 1 minute intervals.

2. Isolation Dampers

a. The damper shall be a flat blade isolation damper. The damper body shall be manufactured from 11 ga. T-304 stainless steel sheet metal. The damper body shall be cylindrical, and have two (2) 3/16" T-304 stainless steel plates with a silicone gasket between them. When fully closed, the damper shall seal when the silicone gasket seats against the inside of the damper body.

b. A 1-1/2" wide X 3/16" thick bolting flange shall be provided on the inlet and outlet of the damper. Flanges shall have a factory drilled bolt hole pattern (7/16" diameter bolt holes), and shall be no more than 4" apart, as recommended in ERDA 76-21, "Nuclear Air Cleaning Handbook".

c. Welding And Cleaning: All "pressure retaining" weld joints and seams shall be continuously welded with no porosities allowed. Joints and seams requiring only intermittent welds such as reinforcement members, shall be intermittently welded. Damper will free be of all burrs, and sharp edges. All weld joints and seams that are a portion of any gasket setting suface, (duct connection flanges), shall be ground smooth and flush with adjacent base metals. All welding procedures, welders, and welder operators shall be qualified in accordance with ASME Boiler and Pressure Vessel Code, Section IX. All welded joints and seams shall be wire brushed to remove heat discoloration.

d. Quality Assurance And Factory Testing: DBT-series dampers shall be manufactured under a quality assurance program that addresses ASME NQA-1, "Quality Assurance Program Requirements for Nuclear Facilities". The damper blade shall be tested in the closed position at +10" w.g. and shall be bubble tight when tested in accordance with ASME N510-1995 Reaffirmed, "Testing of Nuclear Air Cleaning Systems". The complete damper pressure boundary shall be leak tested at +15" water gage and have a maximum leak rate of 0.0005 cfm per cubic foot of housing volume.

e. Manual Actuator: Actuator is installed and equipped with an 8" hand wheel. Actuator shall be quarter-turn manual worm geared. Actuator housings and covers are cast aluminum, worms are heat-treated carbon steel, worm wheels are cast ductile iron, input shafts are carbon steel, shaft and worm seals are BUNA-N rubber, housing to cover seals are silicon sealant, bushings are oil impregnated copper nickel steel alloy. Actuator maximum output torque is 4,500 in. lbs., with a gear ratio of 30:1.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. Install filter frames according to manufacturer's written instructions.

B. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.

C. Install filters in position to prevent passage of unfiltered air.

D. Install filter gage for each filter bank.

E. Install filter gage static-pressure tips upstream and downstream from filters to measure pressure drop through filter. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.

F. Coordinate filter installations with duct and air-handling unit installations.

G. Electrical wiring and connections are specified in Division 26 Sections.

H. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

I. Each filter shall be identified in accordance with the identification system indicated on the schedule or drawings with labels complying with Division 23 Section “Identification for HVAC Piping and Equipment”. Identification on unit shall be readable from the floor through the primary service access opening.

## 3.2 EQUIPMENT AND MATERIALS PROTECTION

A. Adequately protect equipment and materials against physical damage. Place equipment and materials in first class operating condition, or return to source of supply for repair or replacement, as determined by A/E. Protect all equipment and materials from moisture at all times. Protect during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting.

## 3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components, filter and filter-frame installation, and electrical wiring, and to assist in field testing. Report results in writing in the O&M Manual.

B. Operate automatic roll filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating. Correct malfunctioning units then retest to demonstrate compliance. Remove and replace units that cannot be corrected with new units and retest.

C. HEPA Filters:

1. Pressurize housing to a minimum of 3.0 in. w.g. (750 Pa) or to designed operating pressure, whichever is higher; and test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks,

## 3.4 CLEANING

A. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new filter media.

B. Utilize temporary high-efficiency filters during testing, balancing, and commissioning to keep all systems clean. Provide temporary obstructions as needed to simulate dirty filter conditions. A complete set of new filters shall be provided no more than 4 days prior to owner's occupancy of building.

3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 234100

SECTION 235100 – BREECHINGS, CHIMNEYS, AND STACKS

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 SUBMITTALS

A. Product Data: Submit for the following:

1. Type B and BW vents.
2. Type L vents.
3. Guy wires and connectors.

B. Shop Drawings: For vents, breechings, and stacks. Include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, methods of field assembly, components, hangers and seismic restraints, and location and size of each field connection.

C. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, and stacks; accessories; and components will withstand seismic forces defined in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
2. Dimensioned Outline Drawings of Breeching and Stacks: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of anchorage devices on which the certification is based and their installation requirements.

D. Warranty: Special warranty specified in this Section.

1.3 QUALITY ASSURANCE

A. Source Limitations: Obtain listed system components through one source from a single manufacturer.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

C. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.

## 1.4 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 077200, "Roof Accessories."

# PART 2 - PRODUCTS

## 2.1 LISTED TYPE B AND BW VENTS

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

1. American Metal Products; MASCO Corporation.
2. Cleaver-Brooks; Div. of Aqua-Chem Inc.
3. Heat-Fab, Inc.
4. Metal-Fab, Inc.
5. Schebler Co. (The).
6. Selkirk Inc.; Selkirk Metalbestos and Air Mate.
7. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 441 and rated for 480-degree F continuously for Type B, or 550-degree F continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 1/4-inch airspace.

D. Inner Shell: ASTM A 666, Type 430 stainless steel.

E. Outer Jacket: Galvanized steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.

G. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

## 2.2 LISTED TYPE L VENTS

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

1. American Metal Products; MASCO Corporation.
2. Heat-Fab, Inc.
3. Metal-Fab, Inc.
4. Schebler Co. (The)
5. Selkirk Inc.; Selkirk Metalbestos and Air Mate

6. Van-Packer Company, Inc.

B. Description: Double-wall metal vents tested according to UL 641 and rated for 570-degree F continuously or 1700-degree F for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.

C. Construction: Inner shell and outer jacket separated by at least a 4-inch airspace filled with high-temperature, ceramic-fiber insulation.

D. Inner Shell: ASTM A 666, Type 316 stainless steel.

E. Outer Jacket: Stainless steel.

F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Termination: Round chimney top designed to exclude 98 percent of rainfall.

## 2.3 GUYING AND BRACING MATERIALS

A. Cable: Four galvanized, stranded wires of the following thickness:

1. Minimum Size: 1/4 inch in diameter.
2. For ID Sizes 4 to 15 Inches: 5/16 inch.
3. For ID Sizes 18 to 24 Inches: 3/8 inch.
4. For ID Sizes 27 to 30 Inches: 7/16 inch.
5. For ID Sizes 33 to 36 Inches: 1/2 inch.
6. For ID Sizes 39 to 48 Inches: 9/16 inch.
7. For ID Sizes 51 to 60 Inches: 5/8 inch.

B. Pipe: As required for bracing and support. Galvanized steel, NPS 1-1/4.

C. Angle Iron: As required for bracing and support. Galvanized steel, 2 by 2 by 0.25 inches.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.2 APPLICATION

A. Listed Type B and BW Vents: Vents for certified gas appliances.

B. Listed Type L Vent: Vents for low-heat appliances.

## 3.3 INSTALLATION OF LISTED VENTS

A. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

B. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.

E. Lap joints in direction of flow.

## 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.

B. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of breechings and stacks that are not completed or connected to equipment.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 235100

SECTION 235200 – STEAM BOILERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.2 SUMMARY

A. This Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers, trim, and accessories for generating hot water.

B. This Section includes packaged steam boilers, trim, and accessories for generating steam with the following configurations, burners, and outputs:

1. Factory assembled boiler on skid with ancillary equipment.
2. Preheat kit with tap for 20 PSI steam supply.
3. Feedwater system with chemical feeder.
4. Blowdown tank with cooling kit connection.
5. Sample cooler.
6. Gas train.
7. Shipping splits in skid to fit through existing doorway.

1.3 SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Submit for boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

1. Design calculations and vibration isolation base details signed and sealed by a qualified professional engineer.

a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

2. Wiring Diagrams: Power, signal, and control wiring.

C. Source quality-control test reports.

D. Field quality-control test reports.

E. Operation and Maintenance Data: For boilers, components, and accessories to include in emergency, operation, and maintenance manuals.

F. Warranty: As specified in this Section.

G. Other Informational Submittals:

1. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
2. Startup service reports.

## 1.4 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. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code with working pressure of 150 psi.

C. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."

## 1.5 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

## 1.6 WARRANTY

A. Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Pressure Vessel: 10 years from date of Substantial Completion.
2. Warranty Period for Burner Head: Five years from date of Substantial Completion.

# PART 2 - PRODUCTS

## 2.1 STEAM BOILERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Fulton VSRT Series.

B. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Aerco
2. Burnham
3. Precision Boilers
4. U.S. Boiler Company
5. Weil-McLain

C. BOILER TYPE

1. Provide a vertical tubeless fully wetted, boiler arranged for automatic firing with natural gas. Boiler shall be complete with low NOx, burner, controls, boiler trim, fittings, and appurtenances necessary for connection and operation.
2. Basis-of-design boiler uses a spiral rib tube design providing for a fully wetted pressure vessel with all flue gases contained within water backed surfaces.
3. The boiler shall have no poured refractory. The burner shall be entirely surrounded by a water backed combustion chamber. The burner shall be uniquely matched to the boiler.
4. Boiler capable of efficiencies up to 86.0%.
5. The boiler shall be insulated with high density fiber insulation limiting insulation losses to less than 0.5% of the boiler nameplate rating.

D. PERFORMANCE

1. Provide documentation of <20ppm NOx at factory test fire over full turndown range.
2. Provide documentation of <10ppm CO at factory test fire over full turndown range.
3. Provide documentation of 10:1 turndown at factory test fire.

E. BOILER DESCRIPTION

1. The pressure vessel design and construction shall be in accordance with Section I or Section IV of the ASME Code for steam boilers. The boiler shall comply with CSD-1 code requirements and be packaged to UL 795 (CUL approval for Canada).
2. The burner location and firing method shall be such that combustion takes place within the water-backed furnace of the boiler. The boiler must be completely refractory free, water backed design, with a helical heat exchanger.
3. It shall be acceptable to either direct vent the boiler using sealed combustion by drawing combustion air in from the outdoors or by drawing air from the mechanical space itself.

    a. Mechanical Space: Adequate combustion air and ventilation shall be supplied to the boiler room in accordance with local codes, the boiler will be provided with damper end switch interlock.

4. The flue gas exhaust stack shall be listed and labeled for use with Category I or Category III appliances, guaranteed appropriate for the application by the manufacturer and supplier of the venting.

    a. The boiler shall be capable of operating with a maximum stack draft of +1.50” w.c. and a minimum stack draft of -0.25” w.c.
    b. The draft system shall be designed to prevent the backflow of exhaust gases through idle boilers.

5. The entire boiler heat exchanger shall be water backed.
6. The boiler heat exchanger design shall be entirely free of tubes.
7. The surface temperature of the boiler jacket will not exceed 140°F because of the completely water backed design.
8. The pressure vessel shell, furnace, heat exchanger and heads shall be SA-53B ERW pipe or SA-516 Grade 70 plate. The thickness shall be no less than .375 inches.
9. The steam space shall be large enough to ensure steam quality of 99.75% down to operating pressures of 12 psig. Steam trays will not be accepted.
10. Boiler vessel design shall ensure that there are minimal thermal stresses. The manufacturer shall provide a FEA to prove low thermal stresses on the pressure vessel.
11. A minimum of four (4) hand-holes shall be provided for access to the water side of the boiler. Hand-hole openings shall be provided at the lower part of the boiler so that the entire bottom of the boiler may be cleaned.
12. The burner must be integral with the boiler, provided by the same manufacturer. The burner should not have any refractory. The burner should be premix type.
13. The boiler shall be mounted on a base made of heavy gauge steel.
14. The boiler must be supplied with a media free, cyclonic air filtration device or an air filter that will capture airborne particles equivalent to a MERV 8 specification to ensure clean air is supplied to the burner.
15. The boiler shall be capable of operating with <20ppm NOx and <10ppm CO throughout the entire turndown range of operation as standard without the use of FGR.
16. The boiler shall be fully assembled and thoroughly tested at the factory at all firing rates. The boiler shall be test fired, test firing shall include filling with water, adjusting operating and safety control settings, and setting combustion points. A minimum of ten (10) combustion points are to be factory configured and tested under live firing conditions. Manufacturer shall supply copies of the test fire report, including fuel air settings and combustion test results. Factory representatives, specifying engineers, installing contractors and/or end users/customers shall all be welcome to witness the boiler being built and/or test fired at the manufacturer's factory.
17. Boiler inspection shall include a hydrostatic test in the presence of an inspector having a National Board Commission. They shall certify a Data Report which shall be delivered with the boiler as evidence of ASME code compliance. In addition to the ASME symbol, the boiler shall bear a National Board Registration Number.
18. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping.

F. STEAM TRIM

1. A water column shall be provided and piped to the boiler at the factory. A gauge glass and drain valve shall be supplied. The water column shall also include the primary low water cutoff prove to automatically shutoff burner operation when water falls below a predetermined level. An auxiliary low water cutoff probe shall be mounted in the boiler shell. The boiler feedwater control shall be controlled by level probes.
2. Feedwater stop and check valve shall be supplied at factory in line to an internally baffled feed connection in boiler shell to prevent thermal shock.
3. Probe type auxiliary low water cutout. Control unit shall have manual reset feature and be factory mounted in vicinity of blowdown valves.
4. The boiler shall be supplied with an ASME Section I or Section IV safety relief valve. The safety relief valve size shall be in accordance with ASME code requirements and set at 150 psig for Section I Pressure Vessels (100 psig for VSRT-9.5) or 15 psig for Section IV Pressure Vessels (The VSRT-9.5 is in accordance with Section I only).

5. 4” dial steam pressure gauge.
6. Additional standard trim shall include quick and slow type bottom blow down valves and water column blow down valve.
7. A surface blowdown connection shall be provided with a manual valve.
8. A steam stop valve shall be provided as standard, to be installed on the internally baffled steam connection in the boiler shell.
9. All external boiler piping shall conform to the A.S.M.E. code and be listed on the boiler’s Data Report, the piping shall be hydrostatically tested at the factory. This pertains to the water feed; blow-off and steam trim piping through the required valves.

G. FUEL BURNING SYSTEM

1. Basic Burner System:

   a. The boiler burner system shall be an integrated certified package to UL-795.
   b. The boiler and burner manufacturers shall be the same company. Burners that are manufactured by third party vendors to the boiler manufacturer or not part of the integrated boiler burner package will not be accepted.
   c. The UL packaged boiler shall be factory fire tested with documented emissions at all firing rates.
   d. The burner combustion air fan shall be constructed to ACMA standard 99-0401-86 Class B or equivalent.
   e. The combustion air fan assembly shall be provided with a 1-year warranty and the combustion air blower motor a 1-year warranty.
   f. Burner air intake shall comprise of a cyclonic air filtration system or air filter equivalent to MERV 8 specification.
   g. Burner be premixed and shall incorporate a stainless steel alloy flame tube. The flame shall be radially distributed around the flame tube providing even heat transfer to the boiler furnace.
   h. The burner head shall be provided with a 5-year warranty.
   i. Control butterfly valves shall be integral to the burner boiler assembly allowing the gas and air valves to be controlled by a dedicated servo drive repeatable to 0.1 of an angular degree.
   j. The entire fuel air ratio control system shall be free of linkages with each control component being individually controlled by dedicated servo drives and fan speed programmable via the flame safeguard keypad.
   k. Burner fuel air ratio shall be controlled by individual servomotors controlling suction side air and gas flow control valve. A common mod motor and linkages for the combustion air, gas valve and fuel valve will not be accepted.
   l. Air flow shall also be controlled via a VFD with closed loop fan speed control. Single speed combustion air fan motor assembles will not be accepted.
   m. Burner fuel air ratio shall be infinitely adjustable throughout the entire firing range with a programmable curve via the Siemens flame safeguard programming pad.
   n. Automatic ignition of the main fuel shall be from a natural gas pilot which will cut off after main flame has been established. Pilot gas train shall include shutoff cock, pilot pressure regulator and pilot solenoid valves.
   o. The pilot assembly shall be removable from the boiler independently of the main burner.

p. Gas train, supplied tested as part of certified packaged boiler shall include:

1) Main gas shutoff valve with pilot line connection.
2) Main gas pressure regulator with vent connection to outside atmosphere.
3) High gas pressure switch with vents piped to outdoors.
4) Low gas pressure switch with vents piped to outdoors.
5) Main gas shutoff valve with integral pressure regulator and automatic valve proving control.
6) Leakage test cock.
7) Factory mounted metering gas flow control valve.
8) Two (2) pressure gauges with gauge cock for burner manifold pressure and gas supply pressure
9) Gas train components sized for a supply pressure of 3-13.8”wc.
10) Where the specifications exceed the requirements of the code and insurance requirements, the specifications shall be followed without exception.
11) Natural gas valve train shall be manufactured by Siemens. No substitutions will be accepted.
12) Gas train components shall be factory assembled and tested by the manufacturer as part of the certified boiler package.

2. Variable speed burner blower motor shall incorporate. Fixed speed fan operation is not acceptable. 3-phase, 480 volt, 60 cycle alternating current shall be used. The three phase TEFC blower motor shall be fully compatible for use with variable frequency drive. Provide a VFD and break resistor. Motor starting shall be accomplished using a soft start device to minimize the current draw at start up.
3. Variable speed modulating burners shall be arranged for a 10:1 turndown. Burner turndowns of less than 4:1 will not be accepted. A documented factory test fire sheet demonstrating turndown compliance shall be provided with each boiler.
4. The burner shall be capable of <20ppm NOx operation at all firing rates. A documented factory test fire sheet demonstrating NOx compliance shall be provided with each boiler.
5. <20ppm NOx emissions shall be achieved via premixed surface combustion. Use of external FGR piping loops and additional control valves is not acceptable.
6. The boiler emissions shall be certified to SCAQMD rule 1146.2 as a standard package for boilers up to and including 50 HP.
7. Fuel and air ratios shall be controlled via electronic parallel positioning and closed loop feedback of fan speed. Fuel air ratio control via mechanical linkage is not acceptable. Fixed speed fan operation is not acceptable. Fuel air ratio via pneumatic air pressure sensing is not acceptable.
8. Burner control system shall provide solid-state flame safeguard protection, pre and post purge, low fire start and modulated firing rate, 2 to 4 second shutdown on flame failure, and 10 second safety lockout. The air inlet damper shall close after each firing cycle to minimize standby loss during the "OFF" periods. All controls shall be wired for 120 volt operation. The flame safeguard system shall be as manufactured by Siemens Inc. using a programming solid state control with keyboard display module and ultra-violet flame detector together with the appropriate auxiliary equipment. The burner control shall be capable of communication with a building automation system.

9. The burner controls shall include Siemens flame safeguard control, control transformer, signal lights, manual firing rate control, and flame failure alarm circuit. Burner motor, burner motor starter, interlocks, ignition equipment, and flame detector shall be factory wired to the control cabinet terminal strip as a certified package. Burner control flame safeguards that are proprietary to the boiler or burner manufacturer are not acceptable.
10. The boiler shall be furnished with a PID load controller for precise steam pressure control. No exceptions.
11. To conform to A.S.M.E. CSD-1 Section CE-110 each panel shall include an integral disconnect switch. The disconnect switch shall be capable of being locked in the open position so that the boiler can be disconnected from all sources of potential. All required fuse blocks along with a control power transformer with primary and secondary fuses shall be integral to the panel. The control panel shall be arranged for a single point power connection.
12. The electrical panel shall be constructed and wiring in a UL508A facility.

H. BOILER CLEANING

1. Contractor shall do a boil-out of the new boiler and deaerator boiler using any commercially available product for this purpose. The boil-out shall include "OVER-THE-TOP" wasting of water. A temporary 2" pipe shall be run from the relief valve tapping to a floor drain to assure that grease and oils are floated to the top and out of the unit. Minimum time for the procedure shall be eight (8) hours of constant water discharge alternating between bottom and top blowdown. At least two (2) complete bottom blowdown and complete refills shall be done.

## 2.2 PACKAGED BOILER SKID

1. Boiler shall be provided on a pre-piped skid capable of fitting through existing doorways into the mechanical room, with shipping splits as required. Skid shall be pre-piped and factory tested prior to arrival at the facility.
2. Skid shall include all necessary components and accessories for a fully-operational boiler system, including (at minimum):

    a. Boiler and burner
    b. Gas train
    c. Preheat kit with 20 psi steam tap to building 20 psi system
    d. Sample cooler
    e. Feedwater tank
    f. Chemical feeder
    g. Blowdown tank
    h. Blowdown cooling kit
    i. Check valves, isolation valves, strainers, relief valves, pressure regulators, pipes, fittings, gauges, thermometers
    j. Connection points for single point electric, steam, water, drain, gas, condensate return, water sample, feedwater vent, blowdown vent, boiler flue

## 2.3 EMERGENCY SHUTDOWN SYSTEM

A. Provide at external door exit from the boiler room, a push-button shutdown station. Station shall have bright red finish and nameplate reading “Emergency Boiler Shut-Down”.

B. Shutdown station shall be wired to a new multi-pole relay in NEMA 1 enclosure. Relay contacts shall be wired into the burner limit circuit of each new boiler.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

B. Examine mechanical spaces for suitable conditions where boilers will be installed.

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

## 3.2 BOILER INSTALLATION

A. Install boiler skid level on new concrete housekeeping pad.

B. Vibration Isolation: Elastomeric isolator pads with a minimum static deflection of 0.25 inch. Vibration isolation devices and installation requirements are specified in Division 23, Section 220548, "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Install gas-fired boilers according to NFPA 54. Boiler, trim, and accessories shall be factory assembled prior to arriving onsite.

D. Install electrical devices furnished with boiler but not specified to be factory mounted.

E. Install control wiring to field-mounted electrical devices.

## 3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to boiler to allow service and maintenance.

C. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

D. Connect steam and condensate piping to supply-, return-, and blowdown-boiler taps with shutoff valve and union or flange at each connection.

E. Install piping from safety relief valves to nearest floor drain.

F. Install piping from safety valves to drip-pan elbow and to nearest floor drain.

G. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

H. Boiler Flue Venting:

1. Install venting kit.
2. Connect full size to boiler connections. Comply with requirements in Division 23, Section 235100, "Breechings, Chimneys, and Stacks."

I. Connect breeching to full size of boiler outlet. Comply with requirements in Division 23, Section 235100, "Breechings, Chimneys, and Stacks" for venting materials.

J. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23, Section 235100, "Breechings, Chimneys, and Stacks" for recirculation duct materials.

K. Ground equipment according to Division 26, Section "Grounding and Bonding for Electrical Systems."

L. Connect wiring according to Division 26, Section 260519, "Low-Voltage, Electrical Power Conductors and Cables."

## 3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    b. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature.
    c. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Remove and replace malfunctioning units and retest as specified above.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 235200

# SECTION 236400 – WATER CHILLERS

## 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 packaged, water or air-cooled, electric-motor-driven, rotary-screw water chillers with the following features:

1. Variable-frequency controller (or motor controller).
2. Microprocessor-based controls complying with ASHRAE 135.

B. Related Sections include the following:

1. Division 28, Section 283500, "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, and ventilation equipment interlocks.

### 1.3 DEFINITIONS

A. EER: Energy-efficiency ratio.

B. IPLV: Integrated part-load value.

### 1.4 SUBMITTALS

A. Product Data: The lists of materials and equipment shall be supported by sufficient descriptive material, such as drawings indicating components, assembly, dimensions, weights and loadings, sound data, required clearances, and location and size of field connections. Indicate equipment, piping and connections, valves, strainers, and thermostatic valves required for complete system. Catalog data published by the manufacturer to demonstrate conformance to the specification requirements shall be provided. Catalog numbers alone will not be acceptable. Listings of items that function as parts of an integrated system shall be furnished at one time.

B. Shop Drawings: Submit a complete set of manufacturer's certified prints of water chiller assemblies, control panels, sections, and elevations, and unit isolation. If the Contractor deems deviations from the contract drawings necessary, details of such deviations, including changes in related portions of the project and the reasons, therefore, shall be submitted with the drawings. Where such deviations require piping or equipment to be supported otherwise than as shown or specified, the details submitted shall include loadings and type and kind of frames, brackets, stanchions, or other supports necessary. Approved deviations shall be made at no additional cost to the Owner. Include the following

1. Assembled unit dimensions.
2. Operating weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Vibration Isolation Calculations and Details: Signed and sealed by a qualified professional engineer.

    a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    b. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.

6. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans drawn to scale and coordinated with the following:

1. Structural supports.
2. Piping roughing-in requirements.
3. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
4. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.

D. Manufacturer Seismic Qualification Certification: Submit certification that water chillers, accessories, and components will withstand seismic forces defined in Division 23, 230529, Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    The term "withstand" means" the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event.

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Source quality-control test reports.

1. Eddy Current Testing: Manufacturer shall be responsible to have all evaporator (and condenser) tubes base line documented prior to chiller start-up via eddy current testing.
2. Vibration Testing: The chiller shall be factory tested both before and after final chiller assembly.

F. Startup service reports.

G. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manual.

## 1.5 QUALITY ASSURANCE

A. ARI Certification: Signed by manufacturer certifying compliance with requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."

B. ASHRAE Certification: Signed by manufacturer certifying compliance with ASHRAE 15 for safety code for mechanical refrigeration. Comply with ASHRAE Guideline 3 for refrigerant leaks, recovery, and handling and storage requirements.

C. Conform to State or local Energy Code Minimum Efficiency Requirements for water chilling packages (Table 14-1C, 14-1L, 14-1K, 14-1M).

D. ASME Compliance: Fabricate and label water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

E. Comply with NFPA 70.

F. Comply with UL 1995.

G. Nameplates: Each major item of equipment shall have the manufacturer's name, serial and model numbers on a plate securely attached to the item.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant or nitrogen.

## 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 and roof penetrations. These items are specified in Division 07, Section "Roof Accessories."

## 1.8 WARRANTY

A. The manufacturer shall warrant the chillers to be free from mechanical defects in material and workmanship under normal use and maintenance for the time period as stated below. Warranty shall be submitted at time of purchase. Manufacturer shall provide two-year parts and labor warranty ending thirty, (30) months from shipment or twenty-four (24) months from start up, whichever occurs first. If any unit part fails because of defects in workmanship or material within two years from start up, the manufacturer will remove the failed part and furnish and install a new part. Compressor for the chiller shall be warranted for five (5) years. Warranty shall include supplying refrigerant charge.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Basis-of-design: YORK YLAA Series

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

1. Carrier
2. YORK
3. Trane
4. Daikin

2.2 MATERIALS AND COMPONENTS:

A. Install and commission, as shown on the schedules and plans, factory as-sembled, charged, and tested air cooled scroll compressor chillers as specified herein. Chiller shall be designed, selected, and constructed using a refrigerant with Flam-mabilityrating of 1, as defined by ANSI/ASHRAE STANDARD 34 Number Designa-tionand Safety Classification of Refrigerants. Chiller shall include not less than two refrigerant circuits above 50 tons (200 kW), scroll compressors, direct-expansion type evaporator, air-cooled condenser, refrigerant, lubrication system, interconnecting wir-ing, safety and operating controls including capacity controller, control center, motor starting components, and special features as specified herein or required for safe, automatic operation.

B. Cabinet:

1. External structural members shall be constructed of heavy gauge, galvanized steel coated with baked on powder paint which, when subject to ASTM B117, 1000 hour, 5% salt spray test, yields minimum ASTM 1654 rating of 6.

C. Operating Characteristics:

1. Provide low and high ambient temperature control options as required to ensure unit is capable of operation from 30°F to 115°F (-1°C to 46°C) ambient temperature.

D. Service Isolation valves:

1. Discharge (ball type) isolation valves factory installed per refrigerant circuit.

E. Includes a system high-pressure relief valve in compliance with ASHRAE 15.

F. Pressure Transducers and Readout Capability

1. Discharge Pressure Transducers: Permits unit to sense and display discharge pressure.
2. Suction Pressure Transducers: Permits unit to sense and display suction pressure.
3. High Ambient Control: Allows units to operate when the ambient temperature is above 115°F (46°C). Includes discharge pressure transducers.

## 2.3 COMPRESSORS

A. Compressors: Shall be hermetic, scroll-type, including:

1. Compliant design for axial and radial sealing.
2. Refrigerant flow through the compressor with 100% suction cooled motor.
3. Large suction side free volume and oil sump to provide liquid handling capability.
4. Compressor crankcase heaters to provide extra liquid migration protection.
5. Annular discharge check valve and reverse vent assembly to provide low-pressure drop, silent shutdown and reverse rotation protection.
6. Initial oil charge.
7. Oil level sight glass.
8. Vibration isolator mounts for compressors.
9. Brazed-type connections for fully hermetic refrigerant circuits.
10. Compressor motor overloads capable of monitoring compressor motor temperature. Provides extra protection against compressor reverse rotation, phase-loss and phase-imbalance.

## 2.4 REFRIGERANT CIRCUIT COMPONENTS

A. Each refrigerant circuit shall include: a discharge service ball type isolation valve, high side pressure relief, liquid line shutoff valve with charging port, low side pressure relief device, filter-drier, solenoid valve, sight glass with moisture indicator, thermostatic expansion valves.

## 2.5 HEAT EXCHANGERS

A. Evaporator:

1. Evaporator shall be brazed-plate stainless steel construction capable of refrigerant working pressure of 450 psig (3,103 kPa) and liquid side pressure of 150 psig (1,034 kPa).
2. Brazed plate heat exchangers shall be UL listed.
3. Exterior surfaces shall be covered with 3/4 in. (19 mm), flexible, closed cell insulation, thermal conductivity of 0.26k BTU/ hr-ft2 -°F/in.) maximum.
4. Water nozzles shall be provided with grooves for field provided ANSI/AWWA C-606 mechanical couplings.
5. Evaporator shall include vent and drain fittings and thermostatically controlled heaters to protect to -20°F (-29°C) ambient in off-cycle.
6. A 40 mesh, serviceable wye-strainer and mechanical couplings shall be provided for field installation on evaporator inlet prior to startup.

B. Air-Cooled Condenser:

1. Coils:

a. Condenser coils shall be constructed of a single material to avoid galvanic corrosion due to dissimilar metals. Coils and headers are brazed as one piece. Integral sub cooling is included. Coils shall be designed for a design working pressure of 650 psig (45 bar). Condenser coil shall be washable with potable water under 100 psi (7 bar) pressure.
b. Internally enhanced, seamless copper tubes, mechanically expanded into aluminum alloy fins with full height collars. Subcooling coil an integral part of the condenser. Design working pressure is 650 psig (45 bar).

2. Low Sound Fans: Shall be dynamically and statically balanced, direct drive, corrosion resistant glass fiber reinforced composite blades molded into a low noise, full-airfoil cross section, providing vertical air discharge and low sound. Each fan shall be provided in an individual compartment to prevent crossflow during fan cycling. Guards of heavy gauge, PVC (polyvinyl chloride) coated or galvanized steel shall be factory installed.
3. Fan Motors: High efficiency, direct drive, 6 pole, 3-phase, insulation class F, current protected, Totally Enclosed Air-Over (TEAO), rigid mounted, with double sealed, permanently lubricated, ball bearings.

## 2.6 CONTROLS

A. General: Automatic start, stop, operating, and protection sequences across the range of scheduled conditions and transients.

B. Power/Control Enclosure: Rain and dust tight NEMA 3R powder painted steel cabinet with hinged, latched, and gasket sealed door.

C. Microprocessor Control Center:

1. Automatic control of compressor start/stop, anti-coincidence and anti-recycle timers, automatic pump down at system shutdown, condenser fans, evaporator pump, evaporator heater, unit alarm contacts, and chiller operation from 0°F to 125°F (-18°C to 52°C) ambient. Automatic reset to normal chiller operation after power failure.
2. Remote water temperature reset via 0 VDC to 10 VDC or 4 mA to 20 mA input signal or up to two steps of demand (load) limiting.
3. Software stored in non-volatile memory, with programmed setpoints retained in lithium-battery-backed real-time-clock (RTC) memory for minimum 5 years.
4. Forty character liquid crystal display, descriptions in English (or Spanish, French, Italian, or German), numeric data in English (or Metric) units. Sealed keypad with sections for Setpoints, Display/Print, Entry, Unit Options and clock, and On/Off Switch.
5. Programmable Setpoints (within Manufacturer limits): display language; chilled liquid temperature setpoint and range, remote reset temperature range, daily schedule/holiday for start/stop, manual override for servicing, low and high ambient cut-outs, low liquid temperature cut-out, low suction pressure cut-out, high discharge pressure cut-out, anti-recycle timer (compressor start cycle time), and anti-coincident timer (delay compressor starts).

6. Display Data: Return and leaving liquid temperatures, low leaving liquid temperature cut-out setting, low ambient temperature cut-out setting, outdoor air temperature, English or metric data, suction pressure cut-out setting, each system suction pressure, discharge pressure (optional), liquid temperature reset through a 4 mA to 20 mA or 0 VDC to 10 VDC input, anti-recycle timer status for each compressor, anti-coincident system start timer condition, compressor run status, no cooling load condition, day, date and time, daily start/stop times, holiday status, automatic or manual system lead/lag control, lead system definition, compressor starts/operating hours (each), status of hot gas valves, evaporator heater and fan operation, run permissive status, number of compressors running, liquid solenoid valve status, load & unload timer status, water pump status.
7. System Safeties: Shall cause individual compressor systems to perform auto shut down; manual reset required after the third trip in 90 minutes. System Safeties include: high discharge pressure, low suction pressure, high pressure switch, and motor protector. Compressor motor protector shall protect against damage due to high input current or thermal overload of windings.
8. Unit Safeties: Shall be automatic reset and cause compressors to shut down if low ambient, low leaving chilled liquid temperature, under voltage, and flow switch operation.
9. Alarm Contacts: Low ambient, low leaving chilled liquid temperature, low voltage, low battery, and (per compressor circuit): high discharge pressure, and low suction pressure.
10. BAS Communications: BACnet MS/TP.

D. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

## 2.7 POWER CONNECTION AND DISTRIBUTION

A. Power Panels:

1. NEMA 3R raintight, powder painted steel cabinets with hinged, latched, and gasket sealed outer doors. Provide main power connections, control power connections, compressor and fan motor start contactors, current overloads, and factory wiring.
2. Power supply shall enter unit at a single location, be 3 phase of scheduled voltage, and connect to individual terminal blocks per compressor. Separate disconnecting means and/or external branch circuit protection (by Contractor) required per applicable local or national codes.

B. Compressor, control and fan motor power wiring shall be located in an enclosed panel or routed through liquid tight conduit.

## 2.8 ACCESSORIES AND OPTIONS

A. Microprocessor controlled, Factory installed Across-the-Line type compressor motor starters as standard.

B. Low Ambient Control: Permits unit operation to 30°F ambient.

   1. High Ambient Control: Permits unit operation above 115°F ambient.

C. Control Power Transformer: Converts unit power voltage to 120-1-60 (500 VA capacity). Factory-mounting includes primary and secondary wiring between the transformer and the control panel.

D. Protective Chiller Panels (Factory or Field Mounted)

   1. Louvered/Wire Panels: Louvered steel panels on external condenser coils painted as per remainder of unit cabinet. Heavy gauge, welded wire-mesh, coated to resist corrosion, around base of machine to restrict unauthorized access.

E. Hot Gas By-Pass: Permits continuous, stable operation at capacities below the minimum step of unloading to as low as 5% capacity (depending on both the unit & operating conditions) by introducing an artificial load on the evaporator. Hot gas by-pass is installed on only one refrigerant circuit.

# PART 3 - EXECUTION

## 3.1 WATER CHILLER INSTALLATION

A. Before water chiller installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, piping, and electrical to verify actual locations, sizes, and other conditions affecting water chiller performance, maintenance, and operations.

B. Chiller shall be installed in accordance with the manufacturer's recommendations, unless otherwise indicated. Install all components and accessories furnished as loose items to be field installed. Installation shall be complete for a fully operable chilled water system. All work shall comply with the American Standard Safety Code for Mechanical Refrigeration and with ASHRAE 15-2004.

   1. Install water chillers on concrete base. Concrete base is specified in Division 230500, Section "Common Work Results for HVAC," and concrete materials and installation requirements are specified in Division 03.
   2. Support of Chillers: Mount water chiller on vibration isolation equipment base as specified in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment."

C. Maintain manufacturer's recommended clearances for service and maintenance.

D. Charge water chiller with refrigerant if not factory charged.

E. Instruction Card: Provide an instruction card for each item of equipment requiring servicing.

F. The controls contractor shall be responsible for conduit and wiring between the interface provided by the chiller manufacturer and the DDC control panel.

G. Electrical Requirements:

1. Unit primary electrical power shall enter the unit at a single location. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule on the drawings.
2. Unit shall be supplied with a field-installed transformer that will supply control circuit power from the main unit power supply. Unit shall be shipped with factory control and power wiring installed.

## 3.2 PIPING CONNECTIONS

A. Chilled-water piping installation requirements are specified in Division 23, Section 232100, "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Furnish and install flow detection devices in chilled water and condenser water piping. Switches shall make contact when flow is established. Flow switches shall be installed in horizontal runs at least 5 pipe diameters downstream from any bend or tee.

C. Provide and install drain valves and vent cocks in piping to each water box. Furnish and install all necessary auxiliary water piping for purge condenser and pump out. Furnish and install all water connections to oil coolers and other such water supply, drain, or vent connections as required by chiller manufacturer.

D. Furnish and install pressure relief piping from pressure relief rupture disc to atmosphere. Water pressure safety relief valve shall be provided and field-installed on the condenser and evaporator side of the water piping by the Division 23 contractor.

E. Provide differential type flow detection devices in chilled water and condenser water piping connecting each chiller. Manufacturer: United Electric 24-013H2012R or approved.

F. Insulation: Chilled water piping and evaporator water boxes shall be insulated by the installing Contractor.

G. Refrigerant Pressure Relief Valve Connections: Extend vent piping to the outside without valves or restrictions.

H. Connect wiring according to Division 26.

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.

## 3.3 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Start-up procedure shall include a visual inspection as well as various technical, mechanical, chemical, and electrical tests as deemed necessary by the factory technician. The factory representative shall coordinate the start-up time with the Contractor and Owner's Representative.

D. Complete installation and startup check(s) according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate water chiller for run-in period according to manufacturer's written instructions.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief is vented outside (for water-cooled water chillers).
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
9. Verify and record performance of chilled (and condenser) water flow and low-temperature interlocks.
10. Verify and record performance of water chiller protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

E. Prepare a written startup report that records the result of tests and inspections. The factory technician shall ascertain that all units are fully operational and arrange repairs if any start-up problems concerning the equipment are evident.

F. 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 two visits to site outside normal occupancy hours for this purpose.

## 3.4 DEMONSTRATION & TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain water chillers. Refer to Division 01,017900, Section "Demonstration and Training."

B. Provide for the training of Owner's designated personnel at a time scheduled by the Owner. Classroom instruction shall be provided in the adjustment, operation, and maintenance of the equipment specified, including pertinent safety requirements. Orient the training specifically to the systems installed rather than a general (canned) training course. Instructors shall be factory-trained concerning all aspects of the subject matter they are to teach. Provide the training necessary to ensure competence in the operation of each system by the operating personnel. Provide instructors, literature, and necessary equipment to train the personnel for an instructional period of not less than eight hours. The entire instruction training session shall be professionally videotaped.

C. Manufacturer shall supply the following literature: Startup, Operation, and Maintenance instructions, Installation instructions, Field wiring diagrams, Trouble-shooting guide, two copies of training video/DVD.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 236400

SECTION 237500 – PACKAGED OUTDOOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes packaged, outdoor, central-station energy recovery units with the following components and accessories:

1. Chilled water coils.
2. Electric heating coils.
3. Economizer outdoor- and return-air damper section.
4. Integral, space temperature controls.

1.2 DEFINITIONS

A. Outdoor-Air Refrigerant Coil: Refrigerant coil in the outdoor-air stream to reject heat during cooling operations and to absorb heat during heating operations. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

B. Outdoor-Air Refrigerant-Coil Fan: The outdoor-air refrigerant-coil fan in units. "Outdoor air" is defined as the air outside the building or taken from outdoors and not previously circulated through the system.

C. Supply-Air Fan: The fan providing supply air to conditioned space. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

D. Supply-Air Refrigerant Coil: Refrigerant coil in the supply-air stream to absorb heat (provide cooling) during cooling operations and to reject heat (provide heating) during heating operations. "Supply air" is defined as the air entering a space from air-conditioning, heating, or ventilating apparatus.

E. VVT: Variable-air volume and temperature.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design unit supports to comply with wind performance requirements, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Wind-Restraint Performance:

1. Basic Wind Speed: 128Vmph**e**.
2. Building Classification Category: II.
3. Minimum 10 lb/sq. ft (48.8 kg/sq. m) multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.

C. Seismic Performance: units shall withstand the effects of earthquake motions determined according to ASCE 7. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

## 1.4 SUBMITTALS

A. Product Data: Include manufacturer's technical data for each unit, including rated capacities, dimensions, required clearances, characteristics, furnished specialties, and accessories.

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. Wiring Diagrams: Power, signal, and control wiring.

C. Delegated-Design Submittal: For unit supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
2. Detail mounting, securing, and flashing of roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
3. Wind Restraint Details: Detail fabrication and attachment of wind and seismic restraints and snubbers. Show anchorage details and indicate quantity, diameter, and depth of penetration of anchors.

D. Manufacturer Wind Loading Qualification Certification: Submit certification that specified equipment will withstand wind forces identified in "Performance Requirements" Article and in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculations.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of wind force and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Manufacturer Seismic Qualification Certification: Submit certification that units, accessories, and components will withstand seismic forces defined in "Performance Requirements" Article and in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment."

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Coordination Drawings: 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. Structural members to which units will be attached.
2. Roof openings
3. Roof curbs and flashing.

G. Field quality-control test reports.

H. Operation and Maintenance Data: For units to include in emergency, operation, and maintenance manuals.

I. Warranty: Special warranty specified in this Section.

## 1.5 QUALITY ASSURANCE

A. ARI Compliance:

1. Comply with ARI 210/240 and ARI 340/360 for testing and rating energy efficiencies for units.
2. Comply with ARI 270 for testing and rating sound performance for units.

B. ASHRAE Compliance:

1. Comply with ASHRAE 15 for refrigeration system safety.
2. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
3. Comply with ASHRAE/IESNA 90.1 for minimum efficiency of heating and cooling.

C. NFPA Compliance: Comply with NFPA 90A and NFPA 90B.

D. UL Compliance: Comply with UL 1995.

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

## 1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components of units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Substantial Completion.
2. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Substantial Completion.

## 1.7 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. Fan Belts: One set for each belt-driven fan.

2. Filters: One set of filters for each unit.

## PART 2 - PRODUCTS

### 2.1 MANUFACTURERS

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:

B. Basis-of-Design: Greenheck

C. Approved Manufacturers:

1. AAON, Inc.
2. Carrier Corporation
3. Trane; American Standard Companies, Inc.
4. Valent Air
5. Greenheck

### 2.2 MANUFACTURED UNITS

A. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, exhaust air blower, energy core, chilled water coil, motorized dampers, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, and an electrical control center. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection

### 2.3 CABINET

A. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.

1. Materials: Rigid urethane injected foam. Foam board not acceptable.

a. Thickness: 2 inch (50.8 mm)
b. Thermal Resistance R13
c. Thermally broken
d. Meets UL94HF-1 flame requirements.
e. Location and application: Full coverage of entire cabinet exterior to include walls, roof of unit, unit base, and doors.

B. Materials: Fiberglass insulation. If insulation other than fiberglass is used, it must also meet the Fire Hazard Classification shown below.

1. Thickness: 2 inch (50.8 mm)
2. Thermal Resistance R8
3. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

4. Location and application: Divider panels between outdoor air and return air/exhaust air streams.

C. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvannealed steel.

D. Supply Air blower assemblies: Blower assembly shall consist of an electric motor and direct-drive fans. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motors shall be capable of continuous speed modulation and controlled by a VFD.

E. Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.

F. Control panel / connections: Units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections. Unit shall be equipped with a Unit Disconnect Switch. Electric heater shall have single point power.

G. Condensate drain pan: Drain Pan shall be an integral part of the unit whenever a cooling option is included. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.

H. P trap: If the unit is equipped with a condensate drain pan, contractor shall provide, or fabricate, and install an appropriate P trap, in accordance with all local and area codes and Best Practices.

I. Energy core:

1. Core Frost Control: Electric Preheat: Shall be provided for frost control of the energy core. Preheater assembly shall include an outdoor air temperature sensor to initiate frost control sequence. Preheater shall comply with UL 1995 and be constructed on a galvanized steel frame.
2. Electric Post-heater: Post-heater shall be SCR control and shall include a temperature sensor with field adjustable set point, located in the outdoor air stream. Heat output of the post-heater shall be infinitely variable.
3. Motorized dampers / Intake Air, Motorized dampers of low leakage type shall be factory installed.

## 2.4 BLOWER

A. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.

B. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.

C. Fan: Direct drive, airfoil plenum fan with steel wheel statically and dynamically balanced. Prop or belt-drive fan not acceptable due to low static capabilities.

D. Blades: Painted steel blades only.

E. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, "Laboratory Methods of Testing Fans for Rating".

## 2.5 MOTORS

A. General: Blower motors greater than 1/2 horsepower shall be "NEMA Premium" unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.

B. Motors shall be 60 cycle, 3 phase 208 volts.

## 2.6 UNIT CONTROLS

A. The unit shall be constructed so that it can function as a stand-alone heating and cooling system controlled by factory-supplied controllers, thermostats and sensors or it can be operated as a heating and cooling system controlled by a Building Management System (BMS). This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors.

B. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.

C. Unit supply fan shall be configured for Variable Volume.

D. Unit exhaust fan shall be configured for Variable Volume.

E. Outside Air / Return Air damper control shall be open/close.

F. Operating protocol: The DDC shall be factory-programmed for BACnet MSTP.

G. Variable Frequency Drive (VFD): unit shall have factory installed variable frequency drive for modulation of the supply and exhaust air blower assemblies. The VFD shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

## 2.7 FILTERS

A. Unit shall have permanent 2 inch (50.8 mm) aluminum filters located in the outdoor air intake and shall be accessible from the exterior of the unit. MERV 8 disposable pleated filters shall be provided in the supply air stream. MERV 13 disposable pleated filters shall be provided in the supply final air stream.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of units.

B. Examine roughing-in for units to verify actual locations of piping and duct connections before equipment installation.

C. Examine roofs for suitable conditions where units will be installed.

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

## 3.2 INSTALLATION

A. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.

1. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger than supported equipment and minimum six inches (150 mm) above finished ground elevation.
2. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
3. Install anchor bolts to elevations required for proper attachment to supported equipment.
4. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
5. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section “Cast-in-Place Concrete”.

B. Equipment Mounting: Install unit on concrete base using elastomeric pads. Comply with requirements for concrete base specified in Division 03, Section 033000, “Cast-in-Place Concrete” Minimum Deflection: 1/4 inch (6 mm).

C. Curb: Install on structure or concrete base, level and secure, according to NRCA's "Low-Slope Membrane Construction Details Manual," Illustration "Raised Curb Detail for Air Handling Units and Ducts.”. Install units on curbs and coordinate penetrations and flashing with construction specified in Division 07, Section 077200, "Roof Accessories." Secure units to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

D. Unit Support: Install unit level on structural curbs. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

E. Install wind and seismic restraints according to manufacturer's written instructions. Wind and seismically restrained vibration isolation curb rails are specified in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment."

## 3.3 CONNECTIONS

A. Install condensate drain, minimum connection size, with trap and indirect connection to nearest roof drain or area drain.

B. Duct installation requirements are specified in other Division 23 Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Connect supply and exhaust ducts to unit with flexible duct connectors specified in Division 23 Section 233300, "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. Report results in writing.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing. Report results in writing.

C. Tests and Inspections:

1. After installing units and after electrical circuitry has been energized, test units for compliance with requirements.
2. Inspect for and remove shipping bolts, blocks, and tie-down straps.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Remove and replace malfunctioning units and retest as specified above.

## 3.5 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Complete installation and startup check(s) according to manufacturer's written instructions and do the following:

1. Inspect for visible damage to unit casing.
2. Inspect for visible damage to furnace combustion chamber.
3. Inspect for visible damage to compressor, coils, and fans.

4. Inspect internal insulation.
5. Verify that labels are clearly visible.
6. Verify that clearances have been provided for servicing.
7. Verify that controls are connected and operable.
8. Verify that filters are installed.
9. Clean condenser coil and inspect for construction debris.

10. Remove packing from vibration isolators.

11. Verify lubrication on fan and motor bearings.
12. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
13. Adjust fan belts to proper alignment and tension.
14. Start unit according to manufacturer's written instructions.

    a. Start refrigeration system.
    b. Do not operate below recommended low-ambient temperature.
    c. Complete startup sheets and attach copy with Contractor's startup report.

15. Inspect and record performance of interlocks and protective devices; verify sequences.
16. Operate unit for an initial period as recommended or required by manufacturer.

17. Calibrate thermostats.
18. Adjust and inspect high-temperature limits.
19. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers.
20. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
21. Measure and record the following minimum and maximum airflows. Plot fan volumes on fan curve.

    a. Supply-air volume.
    b. Exhaust-air volume.
    c. Outdoor-air intake volume.

22. After startup and performance testing and prior to Substantial Completion, replace existing filters with new filters.

## 3.6 CLEANING AND ADJUSTING

A. 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 two visits to site during other-than-normal occupancy hours for this purpose.

B. After completing system installation and testing, adjusting, and balancing unit and air-distribution systems, clean filter housings and install new filters.

## 3.7 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit. Refer to Division 01, Section 017900, "Demonstration and Training."

## 3.8 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 237500

# SECTION 238200 – HEATING AND COOLING 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 DEFINITIONS

A. BAS: Building automation system.

### 1.3 SUBMITTALS

A. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.

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. Wiring Diagrams: Power, signal, and control wiring.

C. Coordination Drawings: Floor plans, 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. Ceiling suspension components.
2. Structural members to which fan-coil units will be attached.
3. Method of attaching hangers to building structure.
4. Size and location of initial access modules for acoustical tile.
5. Items penetrating finished ceiling, including the following:

    a. Lighting fixtures.
    b. Air outlets and inlets.
    c. Access panels.

6. Perimeter moldings for exposed or partially exposed cabinets.

D. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Operation and Maintenance Data: For fan-coil units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, Section 017823, "Operation and Maintenance Data," include the following: Maintenance schedules and repair part lists for motors, coils, integral controls, and filters.

F. Warranty: Special warranty specified in this Section.

## 1.4 QUALITY ASSURANCE

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

## 1.5 COORDINATION

A. Coordinate layout and installation of fan-coil units and suspension system components with other construction that penetrates or is supported by ceilings, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.

## 1.6 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:

a. Compressor failure.
b. Condenser coil leak.

2. Warranty Period: Four years from date of Substantial Completion.
3. Warranty Period (Compressor Only): Five years from date of Substantial Completion.
4. Warranty Period (Condenser Coil Only): Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 CONCEALED AIR HANDLING UNITS

A. Basis-of-Design Product: Enviro-Tec

B. Manufacturers:

1. Carrier Corporation
2. Price Industries
3. Daikin
4. Johnson Controls
5. Nailor
6. Enviro-Tec

C. General:

1. Furnish and install Vertical Concealed Direct Drive Fan Coil Unit where indicated on the plans and specifications. Units shall be completely factory assembled, tested and shipped as one piece except where noted.
2. All units shall be capable of meeting or exceeding the scheduled capacities for cooling, heating, and air delivery. All unit dimensions for each model and size shall be considered maximums. Units shall be ETL listed in compliance with UL/ANSI Standard 60335-2-40 / CSA C22.2 No. 60335-2-40 and be certified as complying with the latest edition of AHRI Standard 440.
3. Unit shall be produced in a facility found to conform to the Quality Management System standard: ISO 9001:2015.

D. Construction:

1. All units shall be fabricated of heavy gauge galvanized steel, able to meet 125 hour salt spray test per ASTM B-117. Casing shall be internally lined with 1/2" thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m. Maximum thermal conductivity shall be .24 (BTU • in) / (hr • ft2 • °F). Insulation must meet all requirements of ASTM C1071 (including C665), UL 181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL 723 and NFPA 90A.
2. All units shall have a minimum 1" duct collar on the discharge. All access panels shall be fully insulated and attached with standard fasteners on at least two opposite sides. No coil, drain piping, or electrical connections shall pass through any access panel.
3. Provide foil faced insulation in lieu of matt faced insulation. Foil insulation shall meet or exceed the requirements stated above, and in addition meet ASTM Standards C-665 and C-1136 for mold, mildew, and humidity resistance. Insulation shall be lined with aluminum foil, fiberglass scrim reinforcement, and #30 kraft paper laminated together with a flame-resistant adhesive. All exposed edges shall be sealed to prevent any fibers from reaching the air stream.
4. Each unit shall be furnished with a one-piece heavy gauge G90 steel drain pan with welded corner construction.

5. Provide a single wall primary drain pan constructed entirely of heavy gauge type 304 stainless steel for superior corrosion resistance. Stainless steel drain pans shall meet or exceed the requirements stated above.

E. Sound:

1. Units shall have published sound power level data tested in accordance with AHRI Standard 350-86.

F. Fan Assembly:

1. Unit fan shall be dynamically balanced, forwardly curved, direct drive DWDI wheel with 18-gauge galvanized chromate coated double inlet scroll. Motor shall include torsion flex suspension mount affixed to scroll using permanently attached mounting studs. Motor mount shall be secured with lock nuts. Blower scroll shall be mounted to fan bulkhead with 18 gauge mounting rail in a manner to allow no metal-to-metal contact with fan bulkhead.
2. Blower motor shall be high efficiency, permanently lubricated sleeve bearing, permanent split-capacitor type with thermal overload protection and three separate horsepower taps. Single speed motors are not acceptable. The fan motor shall be unpluggable from the electrical leads at the motor case for simplified removal.

    a. Provide three-speed fixed electrically commutated motor (ECM) or constant torque spoked rotor type adjustable ECM to enhance efficiency and reduce future maintenance, paired with a PWM speed control board ICM Sync (2-10V) or ICM Select (3-speed).

G. Coils:

1. All unit coils shall be rated in accordance with AHRI 410.
2. All coils shall be 1/2" O.D. seamless copper tubes with collared and corrugated aluminum fins. All tubes shall be mechanically expanded to provide an efficient bond between tube and fin. All water coils shall be provided with a manual air vent fitting to allow for coil venting. Valve core type vent fittings shall not be accepted.
3. All chilled water coils shall have 0.0055" thick aluminum fins and 0.016" tube wall thickness.
4. All coils shall be hydrostatically tested with air under water at 450 PSIG minimum pressure and rated for a maximum of 450 PSIG working pressure at 200°F.

H. Options:

1. Coil casing shall be fabricated from 304 Stainless Steel.
2. Provide automatic air vents, in lieu of manual air vents.
3. Fin material shall be (0.0075" thick aluminum) (0.0075" thick copper).
4. Tube wall thickness shall be 0.025" on chilled water or hot water coils.
5. Provide with float switch

I. Filter:

1. Unit shall have a High Efficiency filter rack suitable for a pleated 2" MERV 8 and a pleated 4" MERV 13. All units shall be provided with throwaway filters factory installed. One complete set of spare throwaway filters shall be provided for each unit.

J. Discharge Plenum Section:

1. Provide a fully insulated integral discharge plenum section, complete with double deflection supply grille. Discharge plenum sections shipped loose for field installation to the units are not acceptable.

K. Mixing Box Section:

1. Provide a fully insulated integral mixing box section, complete with return and outside air dampers. Mixing box sections shipped loose for field installation to the units are not acceptable.

L. Electrical:

1. Units shall be furnished with a single point power location and electrical junction box for motor and other electrical terminations.

M. Electrical Heat Section:

1. Provide an integral electric resistance heating assembly with the heating capacity, voltage, kilowatts, and stages as shown in the schedule.
2. The heater assembly shall be designed and rated for installation to the air handling unit without the use of duct extensions or transitions between the unit and the heater assembly. The heater shall be factory assembled and completely wired for single point power connection.
3. The heater and unit assembly shall be listed for zero clearance and shall meet all NEC requirements and be ETL listed with the unit as an assembly in compliance with UL/ANSI Standard 60335-2-40 / CSA C22.2 No. 60335-2-40, or UL 1995/CSA C22.2 No 236. (UL 60335-2-40).
4. All heating elements shall be open coil design using Ni-Chrome wire mounted in ceramic insulators and housed in an insulated heavy gauge galvanized steel housing. All elements shall terminate in a machine staked stainless steel terminal secured with stainless steel hardware for corrosion resistance. The element support brackets shall be spaced no greater than 3-1/2" on center. All internal wiring shall be rated for 105°C minimum.
5. All heaters shall include overtemperature protection and shall be interlocked with the fan. All heater elements shall be single stage unless noted otherwise on the plans.
6. An incoming line power distribution block shall be provided. The power distribution block shall be designed to accept incoming power wiring capable of carrying 125% of the calculated load current.
7. A manual reset secondary thermal limit is standard

N. Piping Packages:

1. Provide a non-insulated, standard factory assembled valve piping package (1/2", 3/4", 1") or piping package parts kit (1¼", 1½") to consist of a 2-way or 3-way, on/off, motorized electric control valve, unions, and two ball isolation valves. Control valves are piped normally closed to the coil. Maximum entering water temperature on the control valve shall be 200°F. Maximum operating pressure shall be 450 PSIG.

   a. Provide y-strainers, and/or pressure-temperature ports for each piping package.
   b. 1/2", 3/4", and 1" Piping packages shall be completely factory assembled, including interconnecting pipe, and shipped separate from the unit for field installation onto the coil, so as to minimize the risk of freight damage.
   c. 1¼" and 1½" Piping packages shall ship as a parts kit, including instructions, for field assembly and installation. 1¼" and 1½" Piping packages shall include unions with integrated P/T ports as a standard feature.

O. Thermostats

1. Provided under Division 230900 Instrumentation and Control Systems.

## 2.2 GREENHOUSE AIR HANDLING UNITS

A. Basis-of-Design Product: Enviro-Tec

B. Manufacturers:

1. Carrier Corporation
2. Price Industries
3. Daikin
4. Johnson Controls
5. Nailor
6. Enviro-Tec

C. General:

1. Furnish and install Blower Coil Units where indicated on the plans and specifications. Units shall be completely factory assembled and tested and shipped as one piece except where noted.
2. All units shall be capable of meeting or exceeding the scheduled capacities for cooling, heating and air delivery. All unit dimensions for each model and size shall be considered maximums.
3. All units shall be of “draw-thru” design with coils, fans, motor, and drain pan completely contained within the unit cabinet.
4. Electric heat to be in the blow-thru configuration.
5. Units shall be cETL listed in compliance with UL/ANSI Std. 60335.
6. All unit coils shall meet or exceed the scheduled cooling and heating capacity, selected and rated in accordance with AHRI 410.
7. Unit shall be produced in a facility found to conform to the Quality Management System standard:
8. ISO 9001:2015.

D. Construction:

1. All units shall be fabricated of minimum 18 gauge galvanized steel, able to withstand a 125 hour salt spray test per ASTM B-117. Panels shall be die-formed “multibend” construction for optimum strength and rigidity.
2. All exterior panels shall be single wall insulated with 1 inch thick fiberglass insulation, rated for a maximum air velocity of 5000 f.p.m.
3. Single wall with 1” thick, 1.6 pound per cubic foot density scrim reinforced foil faced insulation.
4. Insulation must meet all requirements of ASTM C1071 (including C665), UL181 for erosion, and carry a 25/50 rating for flame spread/smoke developed per ASTM E-84, UL723 and NFPA 90A. In addition to using adhesive complying with NFPA 90A, the insulation shall incorporate a secondary mechanical fastener attached to the unit casing wall. Adhesive as the only method of fastening the insulation to the casing is not acceptable.
5. Provide foil faced insulation in lieu of matt faced insulation. Foil insulation shall meet or exceed the requirements stated above, and in addition meet ASTM Standards C-665 and C-1136 for mold, mildew, and humidity resistance. Insulation shall be lined with aluminum foil, fiberglass scrim reinforcement, and #30 kraft paper laminated together with a flame-resistant adhesive. All exposed edges shall be sealed to prevent any fibers from reaching the air stream.
6. All access panels shall be fully insulated and attached with standard fasteners on at least two opposite sides. No single access panel shall be larger than 30” x 36” for safety and ease of handling. No coil or drain piping or electrical connections shall pass through any access panel.
7. Each unit shall be furnished with a one-piece heavy gauge G90 steel or optional IAQ stainless steel drain pan with welded corner construction. Drain pan shall be insulated with minimum 1/8” closed cell foam. All units shall be provided with 9/16” diameter hanger rod holes in the top and bottom panels for “through-bolt” type suspension installation.
8. Spring type unit mounting vibration isolators shall be provided by the unit manufacturer.
9. All units shall have a minimum 1” duct collar on both the discharge and return.
10. Provide a single wall primary drain pan constructed entirely of heavy gauge type 304 stainless steel for superior corrosion resistance. Stainless steel drain pans shall meet or exceed the requirements stated above.

E. Fan & Motor Assembly:

1. All units shall be furnished with double inlet forward curved centrifugal blowers statically and dynamically balanced for smooth operation. Blower wheels shall be mounted directly on the motor shaft. Belt driven blowers are not acceptable.
2. Fan motors shall be electronically commutated with thermal overload protection and a constant torque operation. RPM control shall not be acceptable. Motors shall feature permanently lubricated ball bearings and operate on three or single phase power.
3. All motors to be installed, factory programmed and wired to the control panel.
4. All motors shall be isolated, depending on motor size, via belly band or torsion flex mount to the blower housing.
5. All motor wiring is to be terminated in a junction box, external to the unit casing.
6. All motors to be operated by single-speed or multi-speed local or remote controller.

F. Coils:

1. All unit coils shall be rated in accordance with AHRI 410.
2. All coils shall be 1/2" O.D. seamless copper tubes with collared aluminum fins. All tubes shall be mechanically expanded to provide an efficient bond between tube and fin. All water coils shall be provided with a manual air vent fitting to allow for coil venting. Valve core type vent fittings shall not be accepted.
3. All chilled water coils shall have aluminum fins and 0.016" tube wall thickness.
4. All coils shall be hydrostatically tested with air under water at 450 PSIG minimum pressure and rated for a maximum of 450 PSIG working pressure at 200°F.
5. Provide 0.025” tube wall thickness

G. Filter Rack Assembly:

1. Unit shall have a High Efficiency filter rack suitable for a pleated 2" MERV 8 and a pleated 4" MERV 13. All units shall be provided with throwaway filters factory installed. One complete set of spare throwaway filters shall be provided for each unit.

H. Inlet Damper Section:

1. Where shown on the plans, the unit manufacturer shall furnish a fully insulated mixing box section (factory assembled and installed inlet damper section) to be mounted next to the unit on base rail (unit & mixing box).
2. The mixing box section shall include heavy gauge formed steel blade dampers in a heavy gauge steel frame with extruded vinyl blade seals and flexible metal jamb seals. Damper drive linkage shall be factory furnished and installed by the unit manufacturer. A field furnished and installed damper actuator can be mounted directly to the damper shaft.

I. Electrical Connection:

1. The unit fan motor shall be completely factory wired to an external electrical enclosure. Each unit shall include fan control package with 24 volt control voltage. Each unit shall include a motor control board, motor circuit fusing, control circuit transformer and terminal strip for connection of field wiring.
2. Motor Control Board Option 1: Motor control shall be provided by a single speed or proportional speed controller mounted on the exterior surface of the control box. Opening the control box to adjust the fan speed shall not be required.
3. Motor Control Board Option 2: Four speed motor control shall be provided with potentiometer type adjustment. Unit to be compatible with BAS.
4. Calibrated airflow curves shall be provided near the control box to aid in testing and balancing.
5. A main incoming power non-fused disconnect switch with lock-out-tag-out ready feature shall be factory furnished and wired by the unit manufacturer for single point power connection.

J. Electrical Heat Section:

1. Where shown on the plans, the unit manufacturer shall furnish an electric resistance heating assembly with the heating capacity, voltage and stages as shown in the schedule. The heater assembly shall be designed and rated for installation to the blower coil unit in the blow thru configuration without the use of duct extensions or transitions between the unit and the heater assembly. The heater assembly shall be factory assembled to the air handling unit and completely factory wired. The heater/unit assembly shall be listed for zero clearance meeting all N.E.C. requirements and be cETL listed in compliance with UL/ANSI Std. 60335.
2. All heating elements shall be open coil design using Ni-Chrome wire mounted in ceramic insulators and housed in an insulated heavy gauge galvanized steel housing. All elements shall terminate in a machine staked stainless steel terminal secured with stainless steel hardware. The element support brackets shall be spaced no greater than 3-1/2" on center. All internal wiring shall be rated for 105°C minimum.
3. All heaters shall include over temperature protection. All heaters shall include a non-adjustable airflow switch.
4. An incoming line power distribution block shall be provided. The power distribution block shall be designed to accept incoming power wiring capable of carrying 125% of the calculated load current.
5. In addition to the above, electric heaters shall include the following options:

    a. Main incoming power disconnect (non-fused)
    b. Main fusing
    c. Magnetic contactors wired for disconnecting operation

6. Electric heat section available uninsulated or with insulated double wall construction.

K. Piping Packages:

1. Provide a non-insulated, standard factory assembled valve piping package (1/2”, 3/4”, 1”) or piping package parts kit (1 1/4” and 1 1/2”) to consist of a 2-way or 3-way, on/off, motorized electric control valve, unions, and two ball isolation valves. Control valves are piped normally closed to the coil. Maximum entering water temperature on the control valve shall be 200°F. Maximum operating pressure shall be 450 PSIG.
2. Provide y-strainers, and/or pressure-temperature ports for each piping package.
3. 1/2”, 3/4”, and 1” piping packages shall be completely factory assembled, including interconnecting pipe, and shipped separate from the unit for field installation onto the coil, so as to minimize the risk of freight damage.
4. 1 1/4” and 1 1/2” piping packages shall ship as a parts kit, including instructions, for field assembly and installation.
5. 1 1/4” and 1 1/2” piping packages shall include unions with integrated pressure temperature ports as a standard feature.

L. Thermostats

1. Provided under Division 230900 Instrumentation and Control Systems.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine areas to receive fan-coil units for compliance with requirements for installation tolerances and other conditions affecting performance.

B. Examine roughing-in for piping and electrical connections to verify actual locations before fan-coil-unit installation.

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

### 3.2 INSTALLATION

A. Install fan-coil units level and plumb.

B. Install fan-coil units to comply with NFPA 90A.

C. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23, Section 230548, "Vibration and Seismic Controls for HVAC Piping and Equipment."

D. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices 48 inches above finished floor.

E. Install new filters in each fan-coil unit within two weeks after Substantial Completion.

### 3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 23, Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:

1. Install piping adjacent to machine to allow service and maintenance.
2. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
3. Connect condensate drain to indirect waste. Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.

B. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23, Section 233300, "Air Duct Accessories." Comply with safety requirements in UL 1995 for duct connections.

C. Ground equipment according to Division 26, Section 260526, "Grounding and Bonding for Electrical Systems."

D. Connect wiring according to Division 26, Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

## 3.4 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.

B. Remove and replace malfunctioning units and retest as specified above.

## 3.5 COMMISSIONING

A. Notify the Commissioning Agent one week prior to startup of equipment.

B. Submit to the Commissioning Agent a Verification of Completion form with the pre-functional check off sheet for each component when it is ready for functional testing.

C. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

END OF SECTION 238200

SECTION 260010 - GENERAL PROVISIONS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the contract, including General and Supplementary Conditions, Division 01 Specification sections, apply to this section.

1.2 SUMMARY

A. Section includes:

1. Definitions and Abbreviations
2. Contract documents
3. Code requirements
4. Permits & fees
5. Submittal requirements
6. Prior approval substitution request
7. Schedule of values
8. Warranty
9. Construction phasing
10. Project closeout requirements

1.3 DEFINITIONS AND ABBREVIATIONS

| | |
|---|---|
| ADA | Americans with Disabilities Act |
| AHJ | Authority Having Jurisdiction |
| Ampacity | Capacity expressed in amperes |
| ASTM | American Society for Testing & Materials |
| Concealed | Hidden from sight as in trench, chases, slabs, furred spaces or hung ceilings |
| Contractor | Shall mean the General Contractor who signs the contract with the Owner |
| EMT | Electrical Metallic Tubing |
| Exposed | 'Not concealed' as defined above |
| Furnish | Supply |
| Galv. | Galvanized |
| IBC | International Building Code |
| IEC | International Energy Code |
| IFC | International Fire Code |
| IEEE | Institute of Electrical & Electronic Engineers |
| IPCEA | Insulated Power Cable Engineers Association |
| Indicated | Indicated on Divisions 1-33 drawings or specifications |
| Install | Install or apply |
| L&I | Labor and Industries |
| Mfg. | Manufacturer |
| NBFU | National Board of Fire Underwriters Pub. 70 (latest edition) |
| NEC | National Electrical Code |

| | |
|---|---|
| NEMA | National Electrical Manufacturers Association |
| NFPA | National Fire Protection Association |
| NREC | Non-Residential Energy Code |
| NRTL | Nationally Recognized Testing Laboratory |
| Provide | Furnish and install |
| SOV | Schedule of Values |
| UL | Underwriters Laboratories, Inc. |

1.4 CONTRACT DOCUMENTS

A. It is the intention of the Division 26 Contract Documents to provide complete and fully operational electrical systems for lighting, power and equipment connections hereinafter specified and/or as shown on the drawings. The work shall include all materials, appliances and apparatus not specifically mentioned herein or noted on the plans, but which are necessary to make a complete working installation.

B. All electrical systems, mounting hardware, labor and other items indicated on the Division 26 drawings, schedules and/or in the specifications shall be included in the Contractor's bid, unless specifically indicated otherwise. The specifications, schedules, diagrams, details and plans are complementary and what is indicated on any is as binding as if indicated on all. Where a conflict exists between what is shown and what is specified, the more stringent shall govern.

C. The contract drawings indicate the extent and the general character and approximate location and arrangement of material and equipment. The documents do not necessarily show the total number of conductors, raceways, boxes, support, access panels, actual routing, block outs, exact device or equipment locations or other such detailed information for the work required. The Contractor shall provide all necessary materials as required by applicable code and product specification for a complete and fully operational installation in accordance with the true intent of the drawings and specifications.

D. All dimensions indicated in the Division 26 drawings are approximate and are indicated as a guideline only. The Contractor shall adjust the exact rough-in locations as necessary to avoid conflict with structural components or other materials and to assure that fixtures, devices, boxes, etc., can be installed as close to the intended location as possible. Working measurements shall be taken from the building and checked with the Architectural and Structural drawings. If conflicts are found the Contractor shall request verification from the Architect before proceeding with that work.

E. The Division-26 documents do not separate work or responsibilities of sub-contractors. The General Contractor is responsible for defining the scope of work of each contractor. This specification recognizes only <u>one</u> contractor. That is the General Contractor who signs the contract with the Owner. Where the term 'The Contractor' is used, it applies to the contractor responsible for the installation of the work described.

## 1.5 CODES

A. The installation of this work shall comply in every way with all governing codes, laws, ordinances and rules applicable for Idaho Statutes.

B. If any conflict occurs between these rules and this specification, the rules shall govern. Nothing in these drawings and specifications shall be construed to permit work not conforming to governing codes. This shall not be construed as relieving the Contractor from complying with any requirements of the plans or specifications which may be in excess of requirements of hereinbefore-mentioned rules and not contrary to same.

## 1.6 PERMITS & FEES

A. Obtain and pay for all licenses, permits, registration fees and inspections required by laws, ordinances and rules governing the work specified herein. Arrange for inspection of the work by inspectors and give the inspectors all necessary assistance in their work of inspection.

B. The Contractor shall include in their bid all utility company fees for temporary service work related to the project in their bid. Utility company fees for permanent power & communications shall be paid for by the owner. The serving utility companies for this project site are Benton PUD (power). No telephone or fiber service is required.

C. Division 26 bid shall include all Labor and Industries permit, inspection, licensing, registration or any other fees associated with the work specified under this Division.

## 1.7 SUBMITTALS

A. It is understood that before the manufacture or installation of any of the work under this contract is carried forward, product data sheets and shop drawings of such work shall be submitted for review.

B. Electronic Submittal Files: Provide electronic (PDF) submittal files for <u>each specification section.</u> PDF files shall be named to identify each section, content, and revision (i.e. 26 24 13 Switchboards r0). To ensure a comprehensive submittal review, Contractor shall provide complete submittals for review (i.e. light fixture product data, lighting control product data, and lighting control shop drawings). Submittals shall be routed and/or tracked through proper channels acceptable to the Architect.

C. Submittals and shop drawings shall be submitted in ample time to avoid delay in any of the work. To ensure there is sufficient time for review, the Contractor shall allow for 15 workdays (M-F) minimum for the transportation, review, processing and return.

D. Items requiring immediate attention due to long lead delivery time or for early construction rough-in are to be identified and shall be submitted in advance of the remainder of the submittal to ensure delivery will coincide with the construction schedule.

E. <u>Architect and Engineer review</u>: The Architect & Engineer's review of the submittals/shop drawings is intended as a check for general conformance with contract documents only. Failure by the Architect or Engineer to discover an error on a submittal does not relieve the contractor of the responsibility for compliance with requirements of the drawings and specifications.

F. Contractor Review: Prior to forwarding to the Architect/Engineer, the Contractor shall review the submittals; mark them with their comments, corrections and approval stamp. The Contractor shall verify that all of the specified requirements are indicated and ensure that the intended items have been identified on the submittal. Submittals shall be clearly marked as to which items, options, colors; models, etc. are being provided. Only the items marked or indicated will be considered as being submitted. If no marks or indications are present on a page only the items conforming to these specifications will apply. Contractor's installing unspecified material will replace that material at their own expense, if in the opinion of the Architect or Engineer that it does not meet specifications, at any time throughout construction. Indicate additional information necessary for the Architect and Engineer to determine the Contractor's intention, color selection, equipment options, etc.

G. Upon request from the Architect or Engineer, provide material samples for examination, color selection and/or quality control. These samples shall be delivered to the Architect's or Engineer's office as directed.

H. The Architect and Engineer's review of the submittals/shop drawings is intended as a check for general conformance with contract documents only. Failure by the Architect or Engineer to discover an error on a submittal does not relieve the Contractor of the responsibility for compliance with requirements of the drawings and specifications.

I. For material requiring color or finish selection 'by Architect', provide separate copies marked 'ATTENTION (ARCHITECTS NAME) – COLOR/FINISH SELECTION REQUIRED'.

J. Provide submittal material as described in Part 1 of each specification section.

| | |
|---|---|
| 260500 | Common Work Results for Electrical Systems |
| 260519 | Low-Voltage Electrical Power Conductors and Cable |
| 260526 | Grounding & Bonding Material |
| 260529 | Hangers and Supports for Electrical Systems |
| 260533 | Raceway and Boxes for Electrical Systems |
| 260540 | Outlet, Junction, and Pull Boxes |
| 260553 | Identification |
| 262726 | Wiring Devices |
| 262813 | Fuses |
| 262816 | Enclosed Switches and Circuit Breakers |
| 262913 | Motor Control and Starters |
| 262933 | Mechanically Held Contactors |

## 1.8 PRIOR APPROVAL SUBSTITUTION REQUEST

A. Items specified are intended to represent quality and general requirements. It is not the intent of these specifications to prohibit other manufacturers from submitting on substitute materials for review as an acceptable equal. Approval granted for substitution requests is made under the assurance that the manufacturer, vendor or sales representative guarantees that the substituted product meets or exceeds the minimum requirements of the specified product.

B. To ensure ample time for review, evaluation and publishing (by addendum), substitution requests must be submitted no later than ten normal business days prior to the bid. Submittals received less than ten normal business days will be at risk of not being published and allowed to bid.

C. If prior approval has not been requested and granted, then the product manufacturer shall be as specified in the contract documents. The Architect/Electrical Engineer reserves the right to reject any product that has not been prior approved or specified.

D. The Contractor shall be responsible for checking equipment dimensions of proposed substitute equipment and be responsible for it fitting the space allowed.

E. Approval of substitution requests are granted with the understanding that any additional cost involved with the installation, re-design or replacement of the substituted material (as a result of the unacceptable performance of that product) shall be paid for by the Contractor.

F. Approved substitutions will be listed in Addenda. Any item listed by addenda may be provided under this contract. Substitution items not listed by Addenda are rejected and shall not be allowed to bid.

G. Substitution after the bid will only be allowed for any one of the following reasons:

1. The Architect, Engineer and Owner approve the substitute product as a better product, at no increased cost.
2. The substitute product is approved as an equal by the Architect, Engineer and Owner and a credit is offered to the Owner. Reference Division 01 documents for substitution request procedures.
3. **The reason for unavailability is discontinuance by the manufacturer.**

1.9 SCHEDULE OF VALUES

A. Within 30 days of the 'Notice to Proceed' the Contractor shall furnish a breakdown of the Division 26 work as indicated in the following Schedule of Values:

Mobilization
Branch Wiring & Equipment Connections, Material
Branch Wiring & Equipment Connections, Labor
Feeder, Material
Feeder, Labor
Power Distribution Equipment/Components, Material
Power Distribution Equipment/Components, Labor
Demobilization & Closeout

## 1.10 WARRANTY AND CORRECTION PERIOD

A. All products provided under Division 26 shall include the manufacturer's standard warranty.

B. In addition to the manufacturer's standard warranty the Contractor shall guarantee the satisfactory operation of all material, equipment and installations provided under this specification and make good, repair or replace, as may be necessary, any defective work, materials or equipment which fail or become defective within a one-year period beginning on the date of substantial completion as established by the Owner and Architect.

# PART 2 - PRODUCTS

## 2.1 MATERIAL REQUIREMENTS

A. All materials shall be new and must be equal to the quality herein specified and as shown on the drawings or a reviewed and accepted equal.

B. All materials furnished shall be tested and approved for the purpose for which they are used, by the Idaho Statutes, approved NRTL facility such as Underwriters Laboratories, Inc.

C. All materials furnished shall be of the standard products of manufacturers regularly engaged in the production of such equipment and shall be the manufacturer's latest standard design.

D. All materials furnished shall be manufactured in accordance with applicable standards of NEMA, ANSI and listed by an approved NRTL.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Workmanship shall be of the best quality and none but competent mechanics shall be employed and shall be under the supervision of a competent foreman. All work shall be complete and present a neat and symmetrical appearance. Non-professional workmanship shall be removed and replaced if so directed by the Architect at no additional cost to the Owner.

B. All work and materials shall be subject to inspections at any and all times by representatives of the Owner and/or Architect.

## 3.2 WORK NOT INCLUDED

A. Mechanical equipment and control wiring unless specifically indicated as provided by Division 26.

## 3.3 ELECTRICAL PHASING REQUIREMENTS

A. Construction phasing unless specifically indicated in the drawing package or specifications is the responsibility of the General Contractor.

## 3.4 EXAMINATION OF SITE

A. Before submitting bids, all bidders on Division 26 work shall visit the site to satisfy themselves as to the nature and scope of all work to be done. The submission of a bid will be taken as evidence that such an examination has been made and difficulties, if any, noted. Later claims for labor, work, materials and equipment required for any difficulties encountered which could have been foreseen, will not be recognized and all such difficulties shall be properly taken care of at no additional expense to the Owner.

## 3.5 MEETINGS AND FIELD OBSERVATION

A. At the discretion of the owner and/or architect, a representative of the Electrical Consultant may attend monthly construction coordination meetings and/or conduct an observational walk-through.

B. At the time of the walk-through, the project foreman shall (upon request) accompany the observation party, and remove cover plates, panel covers, ceiling tiles, access panels and unlock doors for the Electrical Consultant, to allow complete observation of the entire electrical system in an efficient manner.

C. The Contractor shall provide all ladders, tools, and hard hats required by the Electrical Consultant. The Contractor shall open any switchboard, panel, box, etc. as requested for the Architect/Engineer's inspection.

D. Upon request by the Project Manager, Architect, Engineer, or Owner, the Contractor shall bring the onsite project red-line (mark-up) drawing set to the monthly meeting for review. Red-line drawings shall be current and updated daily, as required.

## 3.6 PROJECT CLOSEOUT

A. Prior to final acceptance of the project the Contractor shall provide Division 26 current and accurate red-line drawings and operation and maintenance manuals (O&M) for all work included in this contract.

B. Red-line drawings shall indicate all corrections and changes made during the construction and shall be neatly and legibly recorded on a set of printed drawings and specifications. Record drawings shall be readily available at the project site for Architect and Engineer progress review. All changes to the Bid Documents shall be recorded by the Contractor at the time they occur and approved prior to implementation. The information to be documented shall include, but is not limited to, the following:

1. Provide accurate locations of all underground site electrical conduit and/or direct burial cable, all service conduits, feeder conduits, and equipment conduits (100A and higher) located below slab within the building and all concealed risers within walls. Indicate dimensions in reference to the building and other landmarks. Indicate burial depth.
2. Indicate the routing of all feeders and concealed risers for switchboards, panelboards and/or equipment rated 100A and higher.
3. Indicate all branch circuit revisions including home run locations, circuits assigned to each device or fixture and changes to location.

4. Attach copies of all electrical addenda, clarification and revision drawings to their appropriate sheets.
5. Revise all panel schedules to indicate circuit and load revisions.
6. Indicate all revisions to the configuration and/or locations of switchgear, switchboards, transformers, panelboards, etc.
7. Indicate any revision to the power distribution architecture on the one-line and/or riser, including section bus amperage or feeder size, disconnecting device type, or other changes made to the designed arrangement.
8. Indicate locations of all access panels and above-ceiling electrical equipment such as LED drivers, lighting control relays, power supplies, etc...
9. Stamp, print or otherwise mark 'Record Drawing' on each sheet of the electrical plans. Mark the specification cover sheet with 'Record Copy'.
10. Indicate all revised device locations.
11. Update all room numbers and nomenclature on every floor plan and reference with the permanent (end user) names and numbers assigned by the Owner.

C. O&M Manuals: Prior to the completion and final acceptance of the contract, the Contractor shall prepare Operating and Maintenance Manuals describing the maintenance and periodic testing requirements of the electrical systems and equipment provided under Division 26. The accepted O&M manuals shall be presented to the Owner at the time of the Owner training and demonstration. Provide manuals as follows:

1. Information contained in the manual shall consist of 8-1/2" x 11" or folded 11"x17" size catalog data, parts list, programming instructions, operation, maintenance, shop drawings, wiring and diagrams installed in a three-ring binder. Catalog data in the manuals shall be neat, clean copies. Full size shop drawings too large for the submittal binder shall be added to the As-Built set. An index shall be provided, which lists all contents in an orderly manner. Tab dividers shall organize all components into logical categories. The binder(s) shall be identified on the cover and binder face with 'Electrical O&M Manuals for [Project Name], [Date], [Volume No. of No.]'.
2. The O&M Manuals shall include the following:

    a. Indicate the vendor, sub-contractor or distributor who supplied each system or material with contact information
    b. Product Data with all options identified
    c. Manufacturer's Shop Drawings
    d. Manufacturer's installation, adjusting, programming and maintenance instructions for lighting control systems & devices
    e. Warranty information
    f. List of spare parts
    g. (60) days of metering data
    h. Provide copies of the electrical inspection sign-off sheets by the electrical AHJ, Department of Labor and Industries or the appropriate municipal authority having jurisdiction

D. At substantial completion, provide one set of legibly marked-up red-line documents to the Electrical Engineer for review and comment. Incomplete or unintelligible documents will be returned to the Contractor if deemed by the Electrical Consultant not to reflect As-Built conditions. Upon acceptance of the red-line document markups, the Engineer will provide copies of the AutoCAD files to the Contractor for final drafting. It shall be the Contractor's responsibility to transpose the Record Drawing information into the AutoCAD files. The Contractor shall employ a drafting service or at their option, the Electrical Consultant to update the ACAD files. Drafting services performed by Coffman Engineers will be billed at the current hourly rate. Include drafting service fees in the Division 26 Bid and provide the Engineer with a clean set of corrected prints for final review.

E. The Contractor shall make changes or revisions to the record copy of the panel schedules by hand. Blank copies or PDF file blank copies will be made available to the contractor. Original spread sheet files will not be provided.

F. After acceptance of the corrected documents the Contractor shall provide to the owner and Electrical Engineer (1) complete set of Division 26 drawings including the updated vendor shop drawings on 24"x36" bond paper and a complete set of AutoCAD & PDF files, one file per sheet and a complete bound set of PDF files including all sheets.

G. The Contractor shall deliver the record documents through proper channels.

H. Owner Training: After the electrical systems are completed, tested and operational and before final acceptance of the electrical work, an indoctrination and instructional period of operating personnel shall be set up. Record the training session on digital format and provide the owner with electronic files. The following is required:

1. The Contractor shall schedule all equipment factory representatives and subcontractors together for system start-up and Owner instruction.
2. The instruction period shall include discussion and presentation of the O&M manuals with tours of equipment locations, explaining access, servicing, maintenance, programming, cleaning, re-lamping procedures, adjustments, etc., for the Owner's signature of acceptance.
3. Tour facility to orientate the Owner with the location of the main service and distribution gear and all branch panel locations. Indicate where all control relays, lighting control modules, dimmers, inverters, remote LED drivers, power supplies, etc. are located above ceilings. Show the owner where all access panels for Division 26-28 equipment are located.
4. Surge Protection: Demonstrate the locations, check for defective units and testing procedures.
5. Lighting Control Systems: Demonstrate control method, programming adjustments, sweep-off time, bypass feature, bypass locations.
6. The Contractor's representative shall be fully knowledgeable of the project and equipment involved. The Contractor shall schedule, organize and supervise all demonstrations. Schedule the demonstrations for all systems supplied by any one vendor to run consecutively.
7. Upon completion of each system demonstration obtain a sign-off from the Owner's authorized representative, stating that the system was demonstrated to be fully operational and complete. Indicate the duration of each instructional period per system. Send copies to the Owner, Architect and Electrical Engineer.

I. Prior to final acceptance, the Contractor shall notify the Engineer one week in advance of the date for the Division 26 punchlist. All material and equipment provided, installed or connected under Division 26 shall be completely installed and operational prior to the scheduled punchlist date. If it is the opinion of the Electrical Engineer that the project is not complete at the time of the scheduled punchlist, the Contractor shall bear the full cost for any additional trips that are required due to incomplete work or non-functional systems. Additional trips will be billed at the customary hourly rate. Upon receipt of the punchlist, the Contractor shall complete all items noted as requiring correction. One additional trip will be allowed to verify that all punchlist items have been completed on a date mutually agreed upon by the Contractor, Owner, Architect and Engineer.

J. Following final acceptance and turnover, contractor shall provide (60) days of demand metering for each panelboard and switchboard as indicated in contract drawings. Peak demand to be measured at 15m intervals and logged. Coordinate meters with owner to ensure that meters are installed in compliance with facility standards and do not obstruct operations and building use. Metering data to be provided in excel format to engineer as a deferred submittal, and provide to owner with final O&M documents.

K. The Contractor shall leave the job in complete order ready for use. All refuse shall be removed. All fixtures, devices and equipment shall be secured, fully equipped, completely cleaned and in good working order. The Owner's Maintenance and Operational personnel shall be thoroughly indoctrinated in the maintenance and operation of electrical systems provided under this Division.

L. All spare and remaining items not used in the project but paid for by the Owner shall be delivered in like-new condition to an on-site storage facility as directed by the Owner.

M. All existing equipment and components requested for salvage by Owner shall be returned to an on-site storage facility as directed by the Owner. Each salvaged equipment shall be wrapped, secured, and tagged with all associated components prior to return.

END OF SECTION 260010

SECTION 260500 - 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, Division 01 Specification sections, apply to this section.

B. Division 07, Penetration Firestopping.

1.2 SUMMARY

A. Section Includes:

1. Electrical equipment coordination and installation.
2. Sleeves for raceways and cables.
3. Grout.
4. Access doors and frames
5. Common electrical installation requirements.

1.3 COORDINATION

A. Coordinate arrangement, mounting, and support of electrical equipment:

1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
3. To allow right of way for piping and conduit installed at required slope.
4. To verify connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions without encroaching the working space or access of other equipment.
5. To maintain access and keep passageways clear.

B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section ‘Access Doors and Frames’.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section ‘Penetration Firestopping’.

## PART 2 - PRODUCTS

### 2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Above Grade Wall Sleeves for Cable: EMT conduit with nylon throat connectors and plastic bushing on each end.

B. Below Grade Footing Sleeves for Conduit: PVC or GRS conduit or pipe.

### 2.2 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, non-metallic aggregate grout, non-corrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

### 2.3 CONCRETE

A. Cast-in-Place concrete for Lighting pole bases, housekeeping pads, transformer pads, etc. shall be the responsibility of each section of Division 26.

B. Cast-in-Place concrete shall comply with Division 3 requirements.

### 2.4 ACCESS DOORS AND FRAMES

A. Access panels shall be the responsibility of each related section of Division 26. All access doors on the project are to be the product of one manufacturer and are to meet the requirements of Specification Section 08310. Closely coordinate the type of access doors and locations with all other Divisions.

B. Where required for access to hidden junction boxes or other Division 26 equipment, the doors shall be sized as necessary to provide proper working clearance.

C. Provide identification tags for all Division 26 access doors.

## PART 3 - EXECUTION

### 3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. 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.

D. 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.

E. Right of Way: Give to piping systems installed at a required slope.

F. All material and equipment shall be installed symmetrical, level, plumb, parallel and perpendicular to other building systems and components, except where otherwise indicated.

G. Devices shall be mounted in compliance with the Americans with Disabilities Act (ADA) or as specified within the limits described below.

1. Unobstructed high forward reach; between 15” and 48”.
2. Unobstructed side reach; between 15” and 48”.
3. Obstructed high forward reach, with obstruction less than or equal to 20”; between top of obstruction and 48”.
4. Obstructed high forward reach, with obstruction between 20” & 25”; between top of obstruction and 44”.
5. Obstructed high side reach less than or equal to 10”; between top of obstruction and 48”.
6. Obstructed high side reach greater than 10” to less than or equal to 24”; between top of obstruction and 46”.

## 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. Sleeves through walls or floors, above grade: Use EMT conduit sleeves unless penetration arrangement requires rectangular sleeved opening.

C. 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.

D. Use pipe sleeves through below grade footing wall.

E. Coordinate sleeve selection and comply with requirements in Division 07 Section ‘Penetration Firestopping’.

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. Fire-Rated Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials.

H. Cut sleeves to length for mounting flush with both surfaces of walls.

I. Unless otherwise noted, extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

J. Seal space outside of sleeves and penetration opening with epoxy grout for concrete and masonry. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

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. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Wall Penetrations: Install steel EMT.

N. Underground, Exterior-Wall Penetrations: No sleeve required. Install PVC Schedule 40 conduit through wall and seal space between wall with masonry grout.

## 3.3 FIRESTOPPING

A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section 'Penetration Firestopping'.

## 3.4 CLEANUP

A. Removal of refuse, debris, cuttings, packaging, cartons, etc. for work provided under Division 26 shall be the responsibility of each related section of Division 26. Cleanup shall be done continually during construction, at sufficient frequency to eliminate hazard to the public, occupants, workmen, the premise and adjacent property.

B. Before acceptance of the installation, carefully clean cabinets, panels, boxes, wiring devices, cover plates, etc., to remove dirt, cuttings, paint, plaster, mortar, concrete, etc. Blemishes to finished surfaces of apparatus shall be removed and new finish equal to the original applied.

## 3.5 TOUCHUP PAINTING

A. Touch up or repair of factory finishes that are scratched or marred in shipment or installation shall be the responsibility shall be the responsibility of each related section of Division 26.

B. Thoroughly clean damaged areas and provide primer, intermediate, and finish coats to suit the degree of damage at each location.

C. Follow paint manufacturer's written instructions for surface preparation and for timing and application of successive coats.

D. Repairs shall be made to the satisfaction of the Owner and/or Architect.

3.6 SAFETY CONDITIONS

A. The Contractor will be solely and completely responsible for conditions of the job site, including safety of all persons and property during performance of the work. This requirement will apply continuously and not be limited to normal working hours. The duty of the Architect to conduct construction observations of the Contractor's performance is not intended to include review of the adequacy of the Contractor's performance measures, in, on, or near the construction site.

B. Furnish, erect and maintain all barricades, guard structures, warning signs, detour signs, lights and flares as may be required to protect and safeguard from injury or damage.

C. Provide bracing, scaffolding, guard rails and protective devices necessary to protect workmen and personnel from personal injury due to electrical installations while on the jobsite.

D. Contractor shall be liable for all damage and injury occurring to the Owner's property on or in the adjacent areas of the work, or which shall occur to any person or property whatsoever by reason of the negligence of the Contractor or any of his employees, or sub- Contractors, or of any breach or violation of the provisions of this agreement, or of any of his duties or obligations under the contract.

END OF SECTION 260500

SECTION 260519 - POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the contract, including General and Supplementary Conditions, Division 01 Specification sections, apply to this section.

1.2 SUMMARY

A. This section includes the following:

1. Low voltage wires and cables rated 600V and less.
2. Medium voltage wire and cables.
3. Connectors, splices, and terminations.

1.3 REFERENCES

A. The following references are incorporated into the requirements of the Work as described herein.

B. Association of Edison Illuminating Companies (AEIC), AEIC CS-8, Specification for Extruded Dielectric Shielded Power Cables Rated 5 through 46 KV

C. ASTM International (ASTM)

1. B3, Standard Specification for Soft or Annealed Copper Wire
2. B8, Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

D. Insulated Cable Engineers Association (ICEA)

1. ICEA S-93-639, 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy
2. ICEA S-95-658, Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy
3. ICEA S-87-640, Standard for Optical Fiber Outside Plant Communications Cable

E. Institute of Electrical and Electronic Engineers (IEEE).

*1.* IEEE 48, IEEE Standard Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
2. IEEE 404, IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500 V to 500 000 V

F. National Electrical Manufacturers Association (NEMA), WC 70, Non-shielded Power Cable 2000 V or Less for the Distribution of Electrical Energy; National Electrical Manufacturers Association.

G. Underwriters Laboratories, Inc. (UL).

1. UL 44, Standard for Safety Thermoset-Insulated Wires and Cables
2. UL 1072, UL Standard for Safety Medium-Voltage Power Cables

H. Telecommunications Industry Association (TIA) Electronic Industries Alliance (EIA)

1. EIA 455-13, FOTP-13, Visual and Mechanical Inspection of Fibers Cables, Connectors and/or Other Fiber Optic Devices
2. EIA 455-59, FOTP-59, Measurement of Fiber Point Defects Using an OTDR

## 1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Factory Test Reports for Medium Voltage Cable: Submit certified report of factory tests performed in accordance with AEIC CS-8, Section E and ICEA S-93-639 for approval prior to shipment of cable from the factory. Provide copy of original X-Y corona discharge plot with the certification.

## 1.5 QUALITY ASSURANCE

A. The contractor shall provide all testing as required by code and these specifications including megger testing of all feeders.

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

C. Comply with NFPA 70.

## 1.6 COORDINATION

A. Verify the final connection requirements with all equipment provided by other Divisions or the owner which require electrical connection.

# PART 2 - PRODUCTS

## 2.1 ACCEPTABLE MANUFACTURERS

A. Subject to compliance with requirements, provide comparable product by one of the following manufacturers:

1. American Insulated Wire Corp; a Leviton Company.
2. Cerrowire/Circle Wire
3. Encore Wire
4. General Cable Corporation
5. Houston Wire and Cable Company

6. Okonite
7. Republic Wire Inc
8. Rio Tinto Alcan Products Corporation
9. Southwire Company
10. Or Approved Equal.

B. For medium voltage cable, the manufacturer shall have a minimum of ten years U.S. experience with manufacturing medium voltage power cable.

## 2.2 WIRE AND CABLE, LOW VOLTAGE (600 VOLTS AND BELOW)

A. Copper Conductors: Comply with NEMA WC 70.

B. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN, XHHW & XHHW2.

C. Conductors larger than #2AWG shall be Type XHHW rated at 75 degrees only.

D. Minimum conductor sizes to be as follows (copper):

| | |
|---|---|
| Lighting and power branch circuits | #12 AWG Min |
| Control circuits | #14 AWG Min |
| Grounding Conductor | #12 AWG Min |

E. Provide conductors with conductivity of not less than 98% at 20 degrees C (68 degrees F).

## 2.3 WIRE AND CABLE, MEDIUM VOLTAGE UNDERGROUND (ABOVE 600 VOLTS)

A. Cables shall be single conductor Ethylene Propylene Rubber (EPR) insulated power cables; medium voltage applications rated 15kV for 12470 volts application.

1. The cables shall be capable of operating continuously in both wet and dry locations at conductor temperature of 105 degrees for normal operations, 140 degrees under emergency operating conditions and 250 degrees under short circuit conditions.
2. Furnished cable shall be UL listed as type MV-105 in accordance with UL 1072.

B. Conductors shall be Class B stranded, concentric, compressed or compact round, soft or annealed copper per Part 2 of ICEA S-93-639.

C. Strand screen shall be extruded EPR compatible semi-conducting compound applied over the conductor. The material shall be compatible with the conductor metal, shall be uniformly and firmly bonded to the overlying insulation and be free stripping from the conductor.

D. Insulation shall be high quality, heat, moisture, ozone and corona resistant EPR compound.

1. The insulation shall contrast in color from the strand screen and insulation shield per AEIC CS-8.
2. Insulation level shall be 133 percent with 220 mils thickness for 15kV cables.

E. Insulation screen shall be extruded EPR compatible semi-conducting compound applied directly over the insulation and with the insulation and overlying metallic shield. The insulation shield shall be free stripping from the insulation and comply with Paragraph D.1 of AEIC CS-8. The insulation shield shall leave no conductive residue on the surface of the insulation after stripping.

F. The strand screen, insulation, and insulation screen shall be applied in a single pass employing a triple tandem extrusion process to provide a virtual corona free cable core. The EPR insulation shall not be exposed to the atmosphere during manufacture.

G. Metallic shield shall be a single 0.005-inch thickness of copper tape, helically applied over the insulation screen material with a minimum 25 percent overlap.

H. Jacket shall be extruded polyvinyl chloride (PVC) material meeting physical and dimensional requirements of ICEA S-93-639, Section 7.

I. Identifying information shall be printed on the jacket in a contrasting color. Information shall consist of manufacturer's name, location code of plant, conductor size, insulation type, insulation thickness, voltage rating and UL designation. Mark "FOR CT USE" where applicable.

J. Size of cable shall be as indicated on the Plans.

K. The cable shall be manufactured and tested in accordance with AEIC CS-6, ICEA S-93-639, and UL 1072.

## 2.4 SPLICES

A. For above grade cable and conductor sizes, provide compression in line splices with premolded GEL cover or heat shrinkable tubing cover: Tyco WCSM or Gelwrap or Approved Equal.

B. For below grade splices in pull boxes, manholes or cable vaults, provide compression type in line splices for two-way connections and C type compression connectors for taps or three-way connections. Cover all below grade splices with Tyco Raychem heat shrinkable tubing (WCSM) or type CRSM-CT cable tap encapsulation kits.

## 2.5 SPLICES (15 KV)

A. Splices in pull boxes, manholes, cable vaults, or equipment for No. 3/0 or larger cable shall be made using either in-line (B below) or modular type kits. Modular splices shall be 600A, 15/25kV, fully shielded, non loadbreak, deadfront, submersible separable connector assemblies.

1. Provide all necessary elbows, extensions, insulating receptacles, connectors, insulating and/or deadend plugs, connecting plugs and ground shield adapters required to form the complete assembly.
2. For cable metallic shields at elbow locations, sealed and insulate with an acceptable heat shrinkable elbow sealing adapter, Tyco ESA series or Approved Equal.

B. 15kV splices shall be heat shrinkable, meeting all the performance requirements of IEEE 404. Splice manufacturer shall have completed IEEE 404 testing to the 105/140C level at an independent testing agency within the United States.

1. Heat shrink splice kits shall have a coextruded semiconducting/insulating layer.
2. Splice kit manufacturer shall provide conductor connectors for use within the splice kit. The entire splice kit and connector shall be the product of one manufacturer.
3. All splices shall be rejacketed with a heat shrinkable sealant lined sleeve covering the entire splice and overlapping onto each cable jacket. Splices shall be Tyco HVS series with HSJ heat shrink rejacketing or Approved Equal.

C. All cable shield grounding connections shall be suitable for a wet environment and compatible with shield material and copper ground conductors.

## 2.6 TERMINATIONS (600V)

A. 600-volt terminations must be crimp compression type bolted to equipment or set screw terminal type in sizes or in equipment not suitable for compression connectors. No. 12 and smaller conductors must utilize eye type compression set terminator when termination is to a bolted or set screw type terminal block or terminal cabinet.

B. For stranded conductors, use connectors and terminal lugs for terminating stranded conductors No. 6 AWG and larger, Thomas and Betts, Ilsco, or Approved Equal solderless connectors.

## 2.7 TERMINATIONS (15 KV)

A. For live front connections to equipment, use termination kits rated for 15 and 25 kV systems, and designed for use with the type of 15 kV cable provided heat shrink type IEEE 48 Class 1A rated for 15kV systems, Tyco-Raychem HVT-Z series, or Approved Equal.

B. Stress cone kits shall include compression applied connector rod, non-tracking rubber modules with cap and molded stress relief, and ground (drain) shield adapters.

C. Connections to deadfront equipment shall be 600 amp non loadbreak connectors where terminating cable No. 3/0 and larger and 200-amp loadbreak connectors where terminating cable No. 2/0 and smaller, as manufactured by Thomas and Betts Elastimold, or Approved Equal. Connectors shall conform to IEEE standards.

D. Connection to live front insulated bus shall be re-insulated with a suitable voltage class heat shrinkable bus insulation tubing or tape and shall be Tyco-Raychem BPTM or Approved Equal.

## 2.8 GROUND WIRE

A. Ground wires shall meet the requirements of Section 260526, *Grounding and Bonding*.

## 2.9 PLASTIC CABLE TIES

A. Cable ties shall be nylon Panduit EH cross-section, PLT locking type, or Approved Equal, with a minimum 250-pound loop tensile strength.

## 2.10 ELECTRICAL TAPES

A. Electrical tapes must be as follows:

1. Insulating tape must be 3M Scotch Super 33+ vinyl electrical type, or Approved Equal.
2. Fire proofing tape must be 3 inch wide, Scotch 3M No. 77 Fire and Electric Arc Proofing tape, or Approved Equal.
3. Glass cloth electrical tape must be Scotch 3M No. 69, or Approved Equal.

## 2.11 CONNECTORS

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. AFC Cable Systems, Inc.
2. Hubbell Power Systems, Inc.
3. O-Z/Gedney; EGS Electrical Group LLC
4. 3M; Electrical Products Division
5. Tyco Electronics Corp.
6. Houston Wire and Cable Company
7. Or Approved Equal.

B. Description: Factory-fabricated connectors of size, ampacity rating, material, type and class for application and service indicated.

## 2.12 ALUMINUM CONDUCTORS

A. Aluminum conductors are not permitted.

## 2.13 FACTORY COLOR INSULATION

A. Phase Conductor Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder and branch-circuit conductors.

1. Color shall be factory applied for sizes smaller than No. 6 AWG.
2. Colors for 480/277-V Circuits:

   a. Phase A: Brown.
   b. Phase B: Orange.
   c. Phase C: Yellow.

3. Colors for 208/120-V Circuits:

   a. Phase A: Black.
   b. Phase B: Red.
   c. Phase C: Blue.

B. Neutral Conductor Identification, 600 V or less; #12 AWG minimum. Use colors listed below for grounded conductors.

1. White

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders for Distribution or Equipment: As scheduled or indicated on the drawings; copper for feeders No. 4 AWG and larger. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Equipment Wiring: All final connections to mechanical and other equipment (where required by the manufacturer) shall be copper only.

C. Branch circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

D. Branch circuits, above grade, concealed and 30 amperes or less: Conduit with pulled in copper conductors.

3.2 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS.

A. Service Entrance: Type XHHW2, single conductors in raceway as indicated on the drawings.

B. Feeders: Type THHN-THWN or XHHW2 (wet location), single conductors in raceway as indicated on the drawings.

C. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN or XHHW2 (wet location), single conductors in raceway as indicated on the drawings.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN or XHHW2 (wet location), single conductors in raceway.

E. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW2, single conductors in non-metallic raceway (PVC).

F. Multi-Conductor Metal Clad cable (MC): MC cable is limited to the following applications:

1. Lighting fixture whips above suspended acoustical tile ceilings from junction box.
2. Final connection between disconnect or junction box and motors, HVAC equipment or other material subject to vibration.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. 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.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Conduits and junction boxes shall be blown out and thoroughly cleaned before any conductors are drawn in. No wires or cables shall be installed until construction work which might damage insulation has been completed.

E. Where spliced in pull boxes, manholes and cable vaults, individually wrap all medium voltage 15,000 Volt cables using the fire proofing tape spirally wound tightly around the conductor.

1. Do not bundle wrap the cables.
2. Use half-lapped wrapping.
3. Apply the fire proofing tape with the coated side toward the conductor and extend the tape one inch into the duct.
4. To prevent the fire proofing tape from unraveling, bundle each individual set of three conductors, and randomly wrap for the entire length of the fire proofing with pressure sensitive glass cloth tape.

F. Install exposed cables parallel and perpendicular to walls, ceilings and surfaces of exposed structural members. Conceal all exposed cable from view and follow structural contours where possible.

G. Support cables according to Division 26 Section 'Hangers and Supports for Electrical Systems'.

H. Identify and color-code conductors and cables according to Division 26 Section 'Identification for Electrical Systems'.

I. Branch circuit home runs shall be single conductors installed in raceway from the panel to a ceiling mounted junction box located in the first room served. Home runs installed below grade shall be run with single conductors in non-metallic conduit below floor and EMT conduit above.

## 3.4 CONNECTIONS

A. 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.

B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150mm) of slack.

D. Certain equipment may require copper only connections and feeders to meet UL Listing requirements or manufacturer's recommendations. For such equipment, the final connection shall be copper only. Equipment served with a Division 26 provided safety switch may use aluminum conductors between the switchboard or panelboard and the safety switch. It shall be the contractor's responsibility to verify that aluminum feeders are acceptable for the equipment being served with the manufacturer with the equipment manufacturer.

E. Splicing on copper pigtails on an aluminum feeder is prohibited.

## 3.5 CONNECTIONS (15 KV)

A. Terminate power cable by means of the specified compression lug or at appropriate terminals in the equipment.

B. Use manual or hydraulic tools as specified for the size of wire by the lug manufacturer. Use the correct size jaws for the indenting tool so that a full stroke is required for proper indentation.

C. For installing the lug, strip the insulation from the conductor only the distance required for inserting the conductor to the full depth of the lug. Properly pencil and taper cable insulation on power conductors where the conductors enter terminating devices as required by the termination manufacturer

D. In addition to meeting the accepted submittal requirements of this Section (See Article 1.04 F, the Engineer may require any cable splicer to make a dummy splice in accordance with the manufacturer's instructions in the presence of the Engineer, verifying the splicer's competence. The Contractor shall furnish all tools, materials and supplies necessary for the dummy splices.

E. The Contractor shall install 15 kV splices as per Article 2.05 of this Section in accordance with the manufacturer's instructions. Use shear bolt connectors or hydraulic tools as specified for the size of wire by the splice manufacturer.

## 3.6 CABLE SHIELDS (15 KV)

A. Connect cable shields to the appropriate ground bus or conductor in manholes, cable vaults and at equipment.

1. Connect the shields of all ends of cables to ground.
2. Connect an appropriate shield adapter at cable ends and terminate the drain wires at terminations and splices.

B. Furnish and install cable shield grounding connections that are suitable for a wet environment and compatible with shield material and copper ground conductors.

## 3.7 BRANCH CIRCUIT AND FEEDER WIRING INSTALLATION

A. Accompanying drawings indicate the circuit assigned to each device or equipment. No deviations are permitted without the Engineer’s approval.

B. Routing of feeders and branch-circuiting is a contractor means and methods within the guidelines of the Division 26 specifications.

C. The drawings are schematic only and do not indicate branch circuit wire counts. It is the Contractor’s responsibility to determine the quantity of wiring required to provide the switching, control and power feeds necessary for the circuit requirements indicated.

D. Power distribution and equipment feeders are indicated on the One-Line diagrams and/or the equipment schedules on the drawings.

E. No more than four branch circuits in any home run unless specifically indicated on the drawings. When more than three current carrying conductors are installed in a single raceway, wire and/or conduit size shall be increased to comply with Article 310 of the NEC.

F. Neutrals: Each single phase, 120V or 277V branch circuit and all feeders requiring a neutral, shall be provided with a dedicated (neutral) conductor. Neutrals shall not be shared between multiple circuits.

G. Ground: All circuits and feeders shall be provided with a ground conductor.

H. Where motor rotation dictates that two conductors be swapped, such swap shall occur at the motor end not the panelboard end or on the load side of any disconnecting device servicing said motor.

I. Neatly train wire inside boxes, equipment, contactors, panelboard and other such electrical equipment. Do not bundle conductors with tie-wraps, etc.

J. Conductor length for parallel feeders shall be identical, minimum size #1/0.

K. Conductors shall be suitably protected against painting or other substances throughout the entire installation process. It shall be the Division 26 Contractor's responsibility to assure that the insulation is in no way susceptible to substances such as paint or plaster. All device openings shall be protected with masking tape, plastic or similar protection and this protection maintained until device installation time.

L. Connections to devices or equipment served by a common circuit shall be pigtail connected. Pigtails shall be limited to the minimum number of conductors required to place the device or equipment into service.

## 3.8 VOLTAGE DROP

A. Wiring Sizes indicated are based on estimated routing. The Contractor is to determine the actual routing required in the field and shall adjust conductor and conduit sizes as required to compensate for voltage drop.

B. Feeders and branch circuits shall be adjusted in conductor size to compensate for voltage drop. It is the Contractor's responsibility to ensure that the wiring is sized properly for the load with a maximum voltage drop of 3% at the end of the circuit. Under-voltage problems created by the failure of the contractor to size wiring for voltage drop shall be corrected at the Contractor's expense.

## 3.9 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports for inclusion in the O&M manuals.

B. Tests and Inspections:

1. Test all conductors and connections for continuity and grounds prior to energizing the circuit or feeder.
2. Megger test all feeders to measure insulation resistance.

3. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for opens, shorts, phase polarity and compliance with requirements of this specification.
4. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260526 – 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 and equipment**.**

1. Equipment ground
2. Enclosure bonding
3. Raceway bonding

### 1.3 SUBMITTALS

A. Provide product data for the following:

1. Exothermic welding
2. Compression fittings

### 1.4 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 UL 467 for grounding and bonding materials and equipment.

C. IEEE Compliance: Comply with applicable requirements of IEEE# Standard 142 pertaining to electrical grounding.

## PART 2 - PRODUCTS

### 2.1 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless green jacket 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. Sizes and types of conductors in four subparagraphs below are typical examples. 28-kcmil bonding cable in first subparagraph below is slightly larger than No. 6 AWG.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) 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 (41 mm) wide and 1/16 inch (1.6 mm) thick.

## 2.2 CONNECTORS

A. 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.

B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions. CADWELD® or approved equal.

## 2.3 GROUNDING ELECTRODES

A. Copper-clad steel ground rods are most common grounding electrode. See Evaluations for discussion on alternative materials. Sectional rods are used when electrodes longer than 10 feet (3 m) are required.

B. Ground Rods: Copper-clad steel, sectional type; 3/4-inch by10 feet (19 mm by 3 m) in diameter.

# PART 3 - EXECUTION

## 3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No.6 AWG and larger, unless otherwise indicated. Equipment ground conductors shall be green insulated, unless otherwise noted.

B. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except as otherwise indicated.
3. Connections to Ground Rods: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

## 3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with all feeders and branch circuits. Conduit (raceway) systems are not an acceptable grounding method.

B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Metal-clad cable runs.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

C. Install ground cables continuous between connections. Splices will not be allowed except where indicated on the drawings. Welded connections or approved compression methods are not considered splices.

D. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

E. The grounding electrode conductor shall be mechanically protected. Where ground cables pass through floor slabs, building walls, etc., and are not in metallic enclosures, provide sleeves of approved nonmetallic material.

## 3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

C. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.

F. Metallic sweeps or end pieces which are part of a non-metallic raceway system shall be bonded per NEC.

G. The self-grounding feature of receptacles shall not be utilized. Provide a grounding conductor from the ground screw on the device to the circuit grounding conductor.Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

## 3.4 COMMUNICATION GROUNDING

A. Provide connections from the TMGB Grounding Busbar to the following:

1. Connect the #2 AWG bare copper ground in conduit or cable tray, from the TMGB to the main electrical service grounding system.
2. Provide one No. 6 AWG green insulated copper conductor from the TMGB to the fire alarm control panel.

B. Provide bonding connections from the communications grounding busbars (TMGB) to equipment racks and cable management ladder with No. 6 AWG green insulated copper conductor.

C. Provide mechanical protection (conduit) for all telecommunications ground conductors. Ground conductors installed in communications cable tray shall be considered mechanically protected.

## 3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal. Make tests at ground rods before any conductors are connected.

    a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    b. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 – 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. Adjust list below to suit Project.
2. Hangers and supports for electrical equipment and systems.
3. Construction requirements for concrete bases and pads.

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.

1.5 QUALITY ASSURANCE

A. Delete first paragraph below if no welding. Retain "Welding certificates" Paragraph in "Submittals" Article if retaining below. AWS states that welding qualifications remain in effect indefinitely unless welding personnel have not welded for more than six months or there is a specific reason to question their ability.

B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Comply with NFPA 70.

1.6 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 comparable product by one of the following manufacturers:

a. Allied Tube & Conduit.
b. Cooper B-Line, Inc.; a division of Cooper Industries.
c. ERICO International Corporation.
d. Thomas & Betts Corporation.
e. Unistrut; Tyco International, Ltd.
f. Or Approved Equal.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. 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.

D. 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.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. 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. Manufacturers: Subject to compliance with requirements, provide products by one of 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.
        5) Or Approved Equal.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless 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. Manufacturers: Subject to compliance with requirements, provide comparable products by one of the following manufacturers:

        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.
        6) Or Approved Equal.

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.

## 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 or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits. Secure raceways and cables to these supports with two-bolt conduit clamps or single-bolt conduit clamps using spring friction action for retention in support channel.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

## 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.

## 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.

C. Field Welding: Comply with AWS D1.1/D1.1M.

## 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 minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Division 09 painting sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

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

END OF SECTION 260529

SECTION 260533 – 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 'Outlet, Junction and Pull Boxes' and 'Low-Voltage Electrical Power Conductors and Cables,

1.3 DEFINITION

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. LFNC: Liquidtight flexible nonmetallic conduit.

H. NBR: Acrylonitrile-butadiene rubber.

I. RNC: Rigid nonmetallic conduit.

J. Raceway: Conduit and tubing used for the installation of electrical wiring.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Fair cost estimate of extra materials. See part 3.

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. Comply with NFPA 70.

C. Aluminum Rigid: UL6.

D. Aluminum EMT: UL797.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. American Conduit by Sapa
5. Anamet Electrical, Inc.; Anaconda Metal Hose.
6. Electri-Flex Co.
7. Manhattan/CDT/Cole-Flex.
8. Maverick Tube Corporation.
9. O-Z Gedney; a unit of General Signal.
10. Wheatland Tube Company.
11. Or Approved Equal.

B. GRS: Galvanized Rigid Steel Conduit: ANSI C80.1.

C. IMC: ANSI C80.6.

D. EMT: ANSI C80.3.

E. EMT Aluminum: 6005 alloy.

F. Rigid Aluminum: High Purity 6063 alloy, T-1 temper.

G. FMC: Zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket.

I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel or die-cast, set-screw or compression type.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

J. Sweeps and bends for 1-1/4" and larger shall be manufactured.

K. Sweeps and bends for limited energy systems shall be as follows:

1. Less than 2"C – bend radius shall be a minimum of six times the internal conduit diameter.
2. 2" or greater – bend radius shall be a minimum of ten times the internal conduit diameter.

L. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

M. Expansion/Deflection Couplings: rated for indoor/outdoor, underground, concrete embedded non-hazardous locations. UL standard 514B. The coupling shall accommodate the following movements without collapsing or fracturing conduit.

1. Axial expansion or contraction up to ¾"
2. Angular misalignment of axes of the coupled conduit runs in any direction to 30º.
3. Parallel misalignment of axes of coupled conduit runs in any direction to ¾"
4. Inner sleeve maintains constant inside diameter in any position
5. Watertight flexible neoprene jacket
6. Corrosion resistant
7. Tinned copper flexible braid ground straps
8. Stainless steel jacket clamps
9. Standard tapered threads

## 2.2 NONMETALLIC CONDUIT AND TUBING

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

1. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. Carlon Electrical Products.
6. CertainTeed Corp.; Pipe & Plastics Group.
7. Condux International, Inc.
8. ElecSYS, Inc.
9. Electri-Flex Co.
10. Manhattan/CDT/Cole-Flex.
11. RACO; a Hubbell Company.
12. Thomas & Betts Corporation.
13. Or Approved Equal.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

D. LFNC: UL 1660

E. Fittings for LFNC: UL 514B.

## 2.3 METAL WIREWAYS

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

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or Approved Equal.

B. Description: Sheet metal sized as required for wire fill, NEMA 250, Type 1 or 3R as required.

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, Screw-cover type, Flanged-and-gasketed type or as indicated.

E. Finish: Manufacturer's standard enamel finish.

## 2.4 BOXES, ENCLOSURES, AND CABINETS

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

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. Randl Industries
9. Robroy Industries, Inc.; Enclosure Division.
10. Scott Fetzer Co.; Adalet Division.
11. Spring City Electrical Manufacturing Company.
12. Thomas & Betts Corporation.
13. Walker Systems, Inc.; Wiremold Company (The).
14. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
15. Or Approved Equal.

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

D. Wiring device outlet boxes for flush mount, 2-1/8” deep (minimum), 4” square with ganged ring, 14 gauge galvanized pressed steel, with return flange and screw retained cover, standard outlet box with stamped knockouts. Lighting fixture boxes same except round.

E. Telecommunications, audio/visual and sound system outlet boxes for flush mount, 2-1/2” deep (minimum), 4-11/16” or 5” square with ganged ring, 14 gauge galvanized pressed steel, with return flange and screw retained cover, standard outlet box with stamped knockouts.

F. Boxes installed in concrete block masonry shall be equipped with a 1-1/2” square cornered tile extensions.

G. Pull and junction boxes 100 cubic inches or smaller: standard outlet box with stamped knockouts.

H. Pull and junction boxes 150 cubic inches or larger: code gauge steel with sides formed and welded, with screw covers unless indicated to be provided with hinged doors. Hinged cabinets shall be lockable with key set to match the panelboards unless noted otherwise.

I. Surface exterior device boxes (wet location) shall be Die Cast Aluminum, 2-5/8” deep, single gang, with (3) 1” threaded outlets, rated for NEMA 3R applications. Basis of design: Raco 5387-0.

J. 5” square boxes for AV and Fire Alarm devices. Depth - 2.875”. Volume -67 cubic inches. Side KO’s - (1)1/2” (2)1” each side. Back KO’s – (3)1/2” & (2)3/4”.: Basis of Design Randle Industries R-55014 box, L-52G034 two-gang ring.

K. Surface exterior GFCI receptacle cover (wet location): Die Cast Aluminum, single gang, lockable cover rated for NEMA 3R applications. Basis of design: Raco 5881-0.

L. Die Cast Aluminum Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum or galvanized, cast iron with gasketed cover.

M. Prohibited materials: Sectional boxes, “handy boxes” and non-metallic boxes indoor.

N. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy or aluminum, Type FD, with gasketed cover.

O. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum galvanized, cast iron with gasketed cover.

P. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic

## 2.5 EXECUTION

## 2.6 RACEWAY APPLICATION

A. Indoors: Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT or IMC.
2. Exposed and Subject to Severe Physical Damage: Rigid steel conduit or IMC. Includes raceways in the following locations or as otherwise indicated:

    a. Loading dock.
    b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.

3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Final Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations. Maximum length 72".
5. Extended Damp or Wet Locations: Rigid steel conduit or IMC.
6. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway or EMT.
7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway or EMT.
8. Raceways for Concealed General-Purpose Distribution of Optical Fiber or Communications Cable: EMT.
9. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

B. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

C. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

D. Aluminum EMT conduit is allowed for above grade installations not subject to damage; concealed in walls or ceilings or exposed in utility spaces. Surface locations below 10' is prohibited.

E. Aluminum Rigid conduit is allowed in above grade locations

## 2.7 INSTALLATION OF CONDUITS AND RACEWAYS

A. General: A conduit system shall be provided for all electrical systems wiring including low voltage (limited energy) systems unless located above accessible suspended acoustical tile ceilings.

B. 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.

C. 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.

D. Complete raceway installation before starting conductor installation.

E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

F. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

G. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

H. Conceal conduit within finished walls, ceilings, and floors, unless otherwise indicated.

I. Conceal conduit within new finished walls, ceilings and floors or where existing structure is exposed to allow concealment of conduit.

J. Surface conduits and raceways are to be neatly installed only where concealment is not possible or in unoccupied areas, mechanical rooms, electrical rooms, or other utility areas. The Contractor shall demonstrate to the Architect that conduits cannot be concealed prior to installing surface conduit in occupied areas. All surface conduits are to be installed prior to painting and painted to match room finish. All surface raceway or conduits in on-concealed applications shall be installed parallel and perpendicular with or at right angles to the building lines and not diagonally to them.

K. Surface conduit and raceway shall be installed level (horizontal or vertical) unless following angular structural or architectural elements.

L. Route exposed conduit to be as concealed from view as possible by using structural or architectural elements to block the view.

M. Raceways Embedded in Slabs:

1. 2” minimum concrete cover is required.
2. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
3. Arrange raceways to cross building expansion joints at right angles with expansion/deflection fittings. See Architectural and Structural drawings for expansion joint locations.

4. Note that some building or local electrical codes may not permit nonmetallic tubing in fire-rated slabs in subparagraph below.
5. Change from RNC, Type EPC-40-PVC, to rigid steel conduit or IMC sweeps before rising above the floor.
6. Conduits stubbed up through floors for connections to free standing equipment shall be provided with a coupling set flush with the finished floor. When not activated the coupling shall be sealed with a deck plug.

N. All rigid conduit shall be reamed after threads are cut not before. All joints in conduit shall be cut square and shall butt solidly into couplings. Running threads will not be permitted.

O. 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.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

Q. 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. Identify each end to indicate destination.

R. 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.

S. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

   a. Outdoor Locations Not Exposed to Direct Sunlight: 125-degree F (70-degree C) temperature change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155-degree F (86-degree C) temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125-degree F (70-degree C) temperature change.

2. Formula in first subparagraph below provides about 15 percent safety factor (extra expansion-contraction capability).
3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.

4. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

T. Flexible Conduit Connections: FMC shall not be used as a predominant type of raceway for branch circuit wiring. Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

U. All conduits located in masonry walls shall be located in the hollow core of these walls. All conduits above floor slab are to be metallic. Conduit in block walls cannot be PVC unless it is encased in concrete (2” minimum) or approved by the Authority Having Jurisdiction.

V. Conduit installed above suspended ceiling systems shall not obstruct the removal and installation of tiles or access to equ8pment located in such space.

W. All conduit serving roof mounted equipment shall be installed horizontally below the roof. Only vertical penetrations to devices or disconnects shall be allowed above the roof. Exception: Exposed conduit may run horizontally on the parapet wall where it is not visible from grade, balconies or windows. Coordinate the installation of conduit attached below roof deck with the roofing installer. Conduits and conductors damaged by roofing screws shall be replaced at no extra expense to the Owner.

X. Conduit systems run horizontally on the roof shall be supported from freestanding piers (as specified under Products). Support piers shall be provided a minimum of 10’-0” o.c. All conduit installed horizontally on the roof shall be galvanized rigid steel with a minimum size of ¾”. Exposed conduit runs are only acceptable on flat roofs where the run is concealed from ground level view. Roof conduits shall be galvanized rigid steel or EMT with watertight fittings.

## 2.8 INSTALLATION OF CONDUIT FOR LIMITED ENERGY WIRING

A. The requirements for the installation of conduit for limited energy systems are in addition to the other requirements specified in this section.

B. Run conduits for telecommunications cabling in the most direct route possible, parallel to building lines with no more than two 90º bends between pull points or pull boxes.

C. Pull boxes shall be sized wide and deep enough for pulling with a length of at least 12 times the diameter of the largest conduit.

D. Pull boxes shall be readily accessible and provided with identification on the cover, box interior and on the conduits entering and exiting the box. Conduit ID for exterior in ground pull boxes is not required.

E. Conduits intended for limited energy systems shall not include any condulet bodies (i.e. LBs) unless they are UL listed for communications cabling.

F. Communications conduit runs shall be bonded on one or both ends in accordance with the NEC and ANSI J-STD-607-A.

G. Conduit runs shall not exceed 100’ without a pull box unless otherwise indicated.

H. Where possible limit the overall conduit length to 150’ total.

I. Conduits shall be sized for the wire fill as recommended in ANSI/TIA/EIA-569-B, unless otherwise specified.

J. All conduit bends shall be long radius.

K. Raceways for Optical Fiber and Communications Cable: Unless otherwise noted, install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
2. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

L. The use of flexible conduit is not allowed for limited energy wiring unless specifically indicated.

M. Limited Energy system conduits shall not be run through the following spaces unless serving a device specified within that area:

1. On top of cellular floors
2. Flammable material storage areas
3. Above boilers, incinerators, steam lines or other heat dissipating equipment.

## 2.9 OUTLET BOX APPLICATION

A. Interior Flush Boxes: Steel knockout type.

B. Interior Boxes Below Ceiling Spaces in Areas Other Than Electrical or Mechanical Rooms: Cast metal Type FB or aluminum Type FD.

C. Interior Boxes Above Accessible Ceilings, in Attics, Electrical, Mechanical or Other Utility Spaces Accessible Only to Authorized Maintenance Personnel: Steel knockout type.

D. Exterior Exposed Boxes: NEMA 3R or 4, Type FB or FS with gasketed cover.

## 2.10 INSTALLATION OF OUTLET BOXES

A. Each device, outlet or junction shall be provided with a galvanized or sherardized pressed steel box. Minimum of 4” square for flush wiring devices with a single or multi-gang plaster ring as required. Box depth shall be as required for the device to be installed.

B. All boxes shall be set level and located to meet accessibility requirements. Boxes determined by the Owner, Architect or Engineer to be inaccessible for service or which interfere with adjacent equipment accessibility, shall be relocated at no extra expense to the Owner.

C. Junction, outlet and pull boxes shall be installed as shown, or as necessary to facilitate pulling of wire and to limit the number of bends to code requirements. Boxes shall be permanently accessible.

D. Any boxes added for the benefit of the Contractor or to meet NEC requirements shall be provided at no additional cost to the Owner.

E. Reference architectural plans, details and specifications for finish wall materials. Provide extension rings as required for acoustical, tackable surfaces, etc.

F. Where devices are shown back-to-back on opposite sides of a wall they shall be installed offset. If the wall is fire rated, then the minimum shall be at least 24" apart with a stud in between.

G. Where multi-gang devices are indicated on the same side of a fire rated wall, provide multiple two-gang boxes as required for the quantity of devices. Devices may be stacked provided the maximum height for switches is not greater than +44" and the minimum height for receptacles and systems outlets is not less than +16" AFF. Provide 4" minimum separation between boxes.

H. Where power and systems devices are shown in the same proximity, locate the devices adjacent to each other at the same mounting heights.

I. Prior to rough-in, devices at counters, cabinets, millwork and casework are to be coordinated with shop drawings and architectural elevations/details. Where knee spaces are provided locate devices below counter. Where devices are shown in locations covered by casework, fixed shelving, etc., confirm intent prior to rough-in.

J. Surface boxes shall be sized to be flush with the outside dimension of the device plates installed. Boxes installed with overhanging device plates shall be replaced at no extra expense to the Owner.

K. 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.

## PART 3 - PRODUCTS

### 3.1 RACEWAY APPLICATION

A. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: IMC.
3. Exposed and Subject to Severe Physical Damage: IMC, RMC
4. Concealed in Ceilings and Interior Walls and Partitions: EMT, IMC, or MC Cable.
5. Embedded in concrete: GRSC, IMC, PVC

6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC or MC Cable, except use LFMC in damp or wet locations.
7. Damp or Wet Locations: GRSC
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 3R, in damp or wet locations.

B. Minimum Raceway Size: 1/2-inch (interior), 3/4-inch for home-runs, buried, or in-slab conduits.

C. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.
3. EMT: Use setscrew steel fittings for dry, interior, concealed locations. Use compression fittings when exposed or in damp or wet interior locations. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

D. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

E. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

F. Install surface raceways only where indicated on Drawings.

G. Do not install nonmetallic conduit where ambient temperature exceeds 120 deg F.

## 3.2 INSTALLATION

A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.

B. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.

C. Do not install raceways or electrical items on any "explosion-relief" walls or rotating equipment.

D. Do not fasten conduits onto the bottom side of a metal deck roof.

E. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

F. Complete raceway installation before starting conductor installation.

G. Arrange stub-ups so curved portions of bends are not visible above finished slab.

H. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within 12 inches (300 mm) of changes in direction.

I. Make bends in raceway using large-radius preformed ells. Field bending shall be according to NFPA 70 minimum radii requirements. Use only equipment specifically designed for material and size involved.

J. Conceal conduit within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.

K. Support conduit within 12 inches (300 mm) of enclosures to which attached.

L. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support. Secure raceways to reinforcement at maximum 10-foot (3-m) intervals.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Arrange raceways to keep a minimum of 2 inches of concrete cover in all directions.
4. Do not embed threadless fittings in concrete unless specifically approved by Architect for each specific location.

M. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or GRSC for raceways.
2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

N. 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.

O. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

P. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

Q. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch and insulated throat metal bushings on 1-1/2-inch and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

R. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

S. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.

T. Cut conduit perpendicular to the length. For conduits 2-inch and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

U. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.

V. Install raceway sealing fittings at accessible locations according to NFPA 70 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 according to NFPA 70.

W. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where an underground service raceway enters a building or structure.
3. Conduit extending from interior to exterior of building.
4. Conduit extending into pressurized duct and equipment.
5. Conduit extending into pressurized zones that are automatically controlled to maintain different pressure set points.
6. Where otherwise required by NFPA 70.

X. Comply with manufacturer's written instructions for solvent welding RNC and fittings.

Y. Expansion-Joint Fittings:

1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed 30 deg F and that has straight-run length that exceeds 25 feet. Install in each run of aboveground GRSC and EMT conduit that is located where environmental temperature change may exceed 100 deg F and that has straight-run length that exceeds 100 feet.
2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:

    a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F temperature change.
    b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F temperature change.
    c. Indoor Spaces Connected with Outdoors without Physical Separation: 125 deg F temperature change.
    d. Attics: 135 deg F temperature change.

3. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per deg F of temperature change for metal conduits.

4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.

Z. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of 72 inches of flexible conduit for recessed and semi-recessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

AA. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

BB. 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. Prepare block surfaces to provide a flat surface for a raintight connection between box and cover plate or supported equipment and box.

CC. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

DD. Locate boxes so that cover or plate will not span different building finishes.

EE. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

FF. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

GG. Set metal floor boxes level and flush with finished floor surface.

HH. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

## 3.3 COORDINATION

A. Coordinate routing and installation of raceways with other trades.

1. Ensure routing and installation will not impede access to other trades' equipment where clearance and access is required
2. Ensure raceway installation is coordinated with furniture and casework.

## 3.4 RACEWAYS AND CABLE INSTALLATION PATHWAYS FOR SIGNAL AND DATA SYSTEMS

A. Installation of Raceways/Pathways for low-voltage signal and data systems shall be in accordance with the applicable portions of ANSI/TIA/EIA-569-A, Commercial Building Standards for Telecommunications Pathways and Spaces.

B. Low voltage wiring systems for signal and data systems may be installed in conduit, cable tray or suspended with J hooks per the NEC. All vertical sections must be in conduit (outside of the communications closet), horizontal sections may be conduit, jhook, or cable tray in accessible ceiling areas. In inaccessible ceiling areas, conduit must be used.

C. Conduits above lay-in ceilings: Do not install cables in conduits that are supported from the ceiling suspension system. All conduits shall be supported independently of the ceiling support system.

D. Conduit fill shall not exceed 40 percent.

E. Bend radii for conduits shall meet the following requirements:

1. If the conduit has an internal diameter of 2 inches or less, the bend radius must be at least 6 times the internal conduit diameter.
2. If the conduit has an internal diameter of more than 2 inches, the bend radius must be at least 10 times the internal conduit diameter.

F. There shall be no more than two 90 degrees bends between pull points in signal and data systems conduit, without derating of the conduit capacity. For each additional 90 degrees bend, the conduit capacity shall be derated by 15 percent. Increase conduit size as required to meet conduit fill requirements of this section with the derated capacity accounted for. Or, provide pull boxes to eliminate 90 degrees bends as necessary to avoid having to derate conduit. Offsets shall be considered as equivalent to a 90 degrees bend. Pull boxes added to conduit runs as of result of this requirement shall be in accordance with this section.

G. Conduits terminated at cable trays shall be bonded to the tray.

H. Exterior conduit shall be 4 inches Schedule 40 PVC with GRC elbows transitioning to 4 inches GRS for Service Entrances. Interior conduit for vertical riser cable shall be GRC, sized per ANSI/TIA/EIA-568-A-5 or as indicated on the Contract Drawings. Interior conduit for horizontal cable shall be EMT, sized per ANSI/TIA/EIA-568-A-5 standards or as indicated on the Contract Drawings.

I. Conduits entering the MDF (Communications Room) room through the floor shall be terminated 4 inches above finished floor. Conduits entering the MDF room from above shall be terminated 4 inches below the finished ceiling, but in no case shall the conduits terminate greater than 12 inches above the cable tray or distribution frame.

J. Conduits and cut-out openings between floors shall be sealed with firestopping material which is removable and reusable, to accommodate adds, moves and changes in the cabling system.

K. All conduits used for routing of low voltage signal and data system cables shall have bushings at all stubouts.

## 3.5 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078400 "Firestopping."

3.6 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

SECTION 260540 - OUTLET, JUNCTION AND PULL BOXES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Refer to Division 01 for submittal requirements and formats.

1.2 SCOPE

A. Provide all outlet, junction and pull boxes required for proper installation of electrical equipment being installed under this work.

1.3 COORDINATION

A. The Contractor shall review all drawings, details and elevations and coordinate with the Architect and equipment supplier prior to rough-in, all installations of wiring devices and equipment. Where equipment is furnished by others, the Contractor shall ascertain the proper voltage, load and connection requirements prior to rough-in.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Boxes: Appleton, Circle AW, Crouse-Hinds, Raco, Steel City, Wiremold or approved equal.

B. Fittings: Appleton, Circle AW, Crouse-Hinds or approved equal.

C. Floor Boxes: Wiremold, FSR, or approved equal.

2.2 OUTLET AND DEVICE BOXES

A. Interior Surface-Mounted in Unfinished Areas: One-piece pressed steel, electro-galvanized, size and depth required by Code, except 4-inch square or 4-inch octagonal minimum. Minimum 14 U.S. gauge, with return flange and screw retained cover.

B. Interior Flush-Mounted: Galvanized pressed steel, knockout type, not less the 4” square, 2-1/8” deep, minimum 14 U.S. gauge, with return flange and screw retained cover. Provide extension rings for all flush boxes. Boxes which occur in concrete block walls shall be equipped with 1 ½” square cornered tile extensions.

C. Interior Surface-Mounted, Finished Areas: Wiremold No. 5700 Series sized to fit standard wiring device, covers specified below.

D. Outlet boxes installed in surface metallic raceway systems shall be shallow boxes manufactured as part of the system.

E. Exterior Mounted: Cast, non-ferrous metal with threaded hubs required. Manufacturers as listed above.

F. Prohibited Materials: Sectional outlet boxes shall not be utilized.

2.3 JUNCTION AND PULL BOXES

A. 100 cubic inches or smaller: Standad outlet box with stamped knockouts.

B. 150 cubic inches or larger: Code gauge stell with sides formed and welded, with screw covers unless shown to have hinged doors. Hinged doors shall have locking device same as furnished for panelboards.

C. Knockouts shall be factory stamped, or formed in the field with a cutting tool to provide a clean symmetrically-cut hole.

D. Interior Areas: Steel, screw cover, Code gauge and size, baked enamel finish.

E. Exterior or Wet areas: Weatherproofed galvanized steel construction with proper gaskets and corrosion resistant fasteners.

F. Device outlets shall be a minimum of 2-1/8” inches deep, minimum 4 inches square.

G. For existing walls, use 2 ½” deep min. cut in box.

H. Prohibited materials: “Handy Boxes”

2.4 FITTINGS

A. Junction boxes or elbows may be cast conduit fittings at Contractor's option. Provide one size larger than raceway for feeders - "mogul-type." Openings accessible at all times. Exterior areas to be cast aluminum with gasketted non-ferrous covers.

PART 3 - EXECUTION

3.1 GENERAL

A. Boxes shall be supported securely and independently. Mount boxes on building surfaces or support with trapeze hanger as described in Raceway Installation. Junction boxes shall not be used unless the number of bends, pulling length, or circuit requirements necessitate their installation. Junction or pullbox openings must be accessible. All boxes must be supported independently of any other building system.

B. Coordinate and locate boxes to ensure accessibility of electrical wiring.

## 3.2 DEVICE BOXES

A. Outlet and device boxes mounted in stud walls shall be attached to two adjacent wall studs using blocking material behind the box to ensure that the box will remain square to the finished wall surface.

B. Outlet and device boxes mounted in masonry walls shall be set at the bottom or top of a masonry unit course.

C. Plaster rings shall be provided for all devices in walls with finished materials such as gypsum wallboard, plaster, etc. Plaster ring shall extend outlet box to within 1/8-inch of finished wall surface including all wall coverings. Coordinate with Architectural finishes prior to rough-in.

D. Grout around all outlet boxes to seal space between box and wall or ceiling materials.

E. Exterior Wall Outlets: Conduit shall not enter the bottom of exterior wall outlet boxes. Conduit shall enter the sides and top only.

F. Multiple Gang Outlet: Install two or more wiring devices shown in one location under a common plate except when outlets are of a different voltages such as telephone and duplex receptacles. Install plates with all edges in continuous contact with finished wall surfaces. Install plates vertically with alignment tolerance of 1/16-inch. Sectional plates are not permitted. No more than one device shall be installed in a single-gang position.

G. Device Locations: Locate switches 6 inches from door casing unless otherwise shown. Outlets mounted above one another shall be on the same centerline. Coordinate exact locations of any special devices with Architect. All outlet heights must comply with all handicap accessibility requirements. Heights to center of outlet mounted vertically shall be as follows unless otherwise shown:

1. Convenience Outlets: +18"
2. Switches: 4'-0"
3. Where different type devices occur adjacent to each other, space outlet boxes so that finish plates will be spaced a minimum of one inch apart at same height.

## 3.3 BLANK COVERS

A. Provide blank covers or plates over all boxes that do not contain devices or are not part of an equipment connection.

## 3.4 LABELING

A. All junction and pull boxes in accessible ceiling spaces and exposed in unfinished areas shall be identified to indicate the branch circuit numbers, feeders, or signal and communication system contained within. Use permanent label. Fire Alarm System shall be red color. Refer to Section 270500 “Common Work Results for Communications” for requirements pertaining to Signal and Communication System.

## 3.5 JUNCTION OR PULL BOXES

A. No box shall be secured to the celling system, HVAC ductwork, or mechanical piping.

B. Pull and junction boxes shall be installed as shown or as necessary to facilitate pulling of wire and to limit the number of bends within code requirements. Boxes shall be permanently accessible and shall be placed only at locations approved by the Architect. Secure boxes rigidly to the building element on which they are mounted, or solidly embed boxes in concrete or mansonry. Identify all pull and junction boxes with a permanent label, neatly showing the individual feeder or electrical system. Installations shall only be above accessible ceiling, crawl spaces, tunnels and in unfinished areas only.

## 3.6 SOUND CONTROL

A. General: The installation of outlet boxes and conduit shall utilize installation methods which minimize sound transmission from one room to adjacent rooms or areas.

B. Installation: Where boxes are mounted in a common wall, they shall wherever possible, be offset horizontally so that they are not mounted back to back. Connect offset boxes with EMT conduit not to exceed 18 inches in length. Where it is not practical to offset boxes, with permission they may be mounted back to back with a minimum clearance of 1/4-inch between boxes and with a sheet of high-density fiberglass between boxes.

## 3.7 EXTENSION RINGS

A. A maximum of one extension ring shall be provided on each junction box.

END OF SECTION 260540

SECTION 260553 - 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 and specification Section 260573 Overcurrent Protective Device Coordination Study.

1.2 SUMMARY

A. Section Includes:

1. Identification for conductors.
2. Warning labels and signs.
3. Equipment identification labels.
4. Miscellaneous identification products.
5. Device plate identification.

1.3 SUBMITTALS

A. Comply with NFPA 70E-2004, Standard for Electrical Safety in the Workplace

B. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

C. ANSI Z535.4-1998, Product Safety Signs and Labels.

D. All material and equipment supplied under this contract shall be identified with an Underwriters Laboratories, Inc. (UL) label.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.4 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, 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 acoustic ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 SELF ADHESIVE LABELS

A. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

B. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

C. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use.

2.2 CONDUCTOR 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. Power-Circuit Conductor Identification; See specification Section 260519.

2.3 IDENTIFICATION TAGS AND LABELS FOR ELECTRICAL EQUIPMENT

A. Equipment Identification Tags: Two-ply phenolic plastic (bake-lite), 1/16-inch-thick, white with black 3/8-inch-high engraved lettering, beveled edges, double stick tape. See 3.02 L.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. White tape with black lettering for normal systems, red for emergency.

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch. Overlay shall provide a weatherproof and UV-resistant seal for label.

2.4 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. 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. First subparagraph below applies to OSHA requirements for building operations and does not reflect the clear working space required by NFPA 70.
3. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."
4. Flash protection markings as required by NEC.

## 2.5 DEVICE PLATE LABELS AND IDENTIFICATION

A. Engraved stainless-steel Type 302, ¼ inch high lettering filled with enamel paint. Black for normal systems, red for emergency systems.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be ¼ inch clear tape with black lettering for normal systems, red for emergency systems. Brady ID PAL, ¾" printer/labeler or equal.

C. Accessible Junction and Pull Boxes Within Buildings: Identify the covers of each junction and pull box with self-adhesive vinyl labels with the wiring system, system voltage and circuit number within. Boxes located in accessible ceilings shall have permanent marker pen on outside cover plate, approximately ½ inch high letters, black for normal systems, red for emergency.

## 2.6 LOCATION INDICATION LABELS ABOVE SUSPENDED CEILINGS

A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Clear tape with black lettering for normal systems, red for emergency.

B. Install label to the bottom (room side) of the suspended ceiling 'T' directly below equipment.

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

F. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

G. Provide engraved, phenolic identification plates for switchboards, switchboard circuit breakers, panelboards, disconnect switches which identify the circuit source (panelboard and circuit number) that supplies the disconnect, per NEC.

H. Equipment Identification, Emergency Systems: All boxes and enclosures, for Article 700 NEC systems must be permanently identified with orange color, both inside and outside.

I. Identify all wiring by type or circuit number located with-in the box on the outside cover using a self-adhesive film equal to Brady ID PAL, ¾" or neatly lettered with permanent black marker pen.

## 3.2 IDENTIFICATION SCHEDULE

A. For conductors larger than #8 AWG, in pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.

B. Where multiple branch circuits with the same color coding are installed in gutters, pull boxes, etc. each branch circuits shall be tagged with circuit number identification. The method of tagging shall be with the adhesive type of marker equal to 'Brady'. The tag shall indicate both panel and circuit number. Markers shall be applied after wire is installed in conduit.

C. All junction boxes above accessible ceilings shall be marked with the panel and circuit numbers of the wires contained inside.

D. Where multiple neutral conductors are allowed and installed in a common raceway or enclosure, they shall not be intermixed. To avoid possible combination of neutral provide factory color stripe corresponding with the phase color on insulation. Provide Brady adhesive style markers with circuit number, where multiple branch circuits with the same color coding are installed in gutters, pull boxes, etc.

E. Warning Labels for Indoor Cabinets, Boxes, and Enclosures: Self-adhesive warning labels or Baked-enamel signs.

1. Comply with 29 CFR 1910.145.
2. Identify system voltage with black letters on an orange background.
3. Apply to exterior of door, cover, or other access.
4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:

    a. Power transfer switches.
    b. Controls with external control power connections.

F. Panelboards: Mount inside door, on dead front, above circuit breakers, unless panelboard is located in a utility-type room, then install nameplate on outside of panelboard above door.

G. Disconnect switches: Mount nameplate on outside of cabinet, near top. Omit nameplate from disconnect switches if located adjacent to equipment.

H. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams and schedules.

1. Labeling Instructions:

a. Indoor Equipment: Engraved phenolic plastic tags self-adhesive. Unless otherwise indicated, provide a single line of text with 3/8-inch high letters on 1-1/2-inch high label; where two lines of text are required, use labels 2 inches high.
b. Outdoor Equipment: Engraved phenolic plastic tags self-adhesive and mechanically attached with No. 4 chrome round head screws.
c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
d. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
e. Mount tags top and centered on outside of covers and doors.
f. Where panels are located in student occupied locations, put ID tags on the inside cover of the panel door.

2. Equipment to Be Labeled:

a. Identification labeling of some items listed below may be required by individual Sections or by NFPA 70.
b. Enclosures and electrical cabinets.
c. Access doors and panels for concealed electrical items.
d. Switchboards.
e. Distribution circuit breakers.
f. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
g. Enclosed switches. 200A and above
h. Enclosed circuit breakers, 200A and above
i. Power transfer switches.
j. Junction boxes.
k. Cabinets.
l. Pull boxes.

I. Equipment Function Labels: On each electrical component associated with the control or disconnecting means of a piece of equipment, install unique designation labels consistent with wiring diagrams, schedules and operation and maintenance of the equipment serviced.

1. Labeling Instructions:

a. Indoor Equipment: Adhesive film label
b. Outdoor Equipment: Adhesive film label with clear protective overlay

2. Equipment to be labeled:

a. Enclosed circuit breakers, 100A or less

b. Safety switches, 100A or less
c. Enclosed controllers.
d. Variable-speed controllers.
e. Push-button stations.
f. Contactors.
g. Remote-controlled switches, manual starters, timer switches, dimmer modules, and control devices.
h. Battery-inverter units.
i. Battery racks.
j. Monitoring and control equipment.

J. Provide engraved metal plates at all switches installed for control of fans, pumps, remotely located lighting, illuminated signs, switched receptacles, contactors or other applications noted on the drawings.

K. Equipment location above suspended ceilings to be identified with adhesive film labels:

1. Relay or lighting control modules.

END OF SECTION 260553

SECTION 260923 – LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 SCOPE

A. Devices and sensor covered in the section are stand alone and do not necessarily interface with devices covered in section 26 09 43.

1.2 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 specification sections, apply to this section.

1.3 DEFINITIONS

A. LED: Light-emitting diode.

B. PIR: Passive infrared.

1.4 SUBMITTALS

A. Product Data: Submit for each type of product provided.

1.5 COORDINATION

A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

1.6 COMMISSIONING

A. Notify the Commissioning Agent one week prior to start up or testing of equipment. Refer to 01 91 13 for a list of commissioning activities.

B. Assist the Commissioning Agent as required to perform the functional testing on the system components and the system as a whole.

PART 2 - PRODUCTS

2.1 TIME CLOCKS

A. Manufacturers: Subject to compliance with requirements, provide products by Intermatic, Tork or equal.

B. Electronic Time Clocks: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 30-A inductive or resistive, 240-volt ac.
2. Program: Two on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
4. Astronomic Time: All channels.
5. Battery backup is required for schedules and time clock.

2.2 OCCUPANCY SENSORS

A. Manufacturer: Subject to compliance with requirements, provide products by Lighting Control System Manufacturer identified in section 26 09 43 unless otherwise specified.

B. General Description: Wall- or ceiling-mounted, solid-state units with a separate relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of one to 30 minutes.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-volt ac, for 13-A tungsten at 120-volt ac, and for one hp at 120-volt ac. Power supply to sensor shall be 24-volt dc, 150-mA, Class 2 power source as defined by NFPA 70.
4. Mounting:

   a. Sensor: Suitable for mounting in any position on a standard outlet box.
   b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure.
   c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.

5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.

C. Dual-Technology Type: Wattstopper DT-300 series (ceiling mount), Wattstopper DT-200 series (wall mount) with separately wired power pack and isolated relay output or approved.

D. Ultra-Sonic Type: Ceiling-mounted Wattstopper UT-300 series with separately wired power pack and isolated relay output or approved.

E. Occupancy Sensor Switches:

1. Toilet Rooms: Wattstopper UW-100 for controlling one circuit; Wattstopper UW-200 for controlling two circuits or approved.
2. All Other Rooms: Wattstopper PW-100 series or approved.
3. Timer Switches: Wall-mounted Wattstopper TS-400 series or approved.

## 2.3 WALL-BOX DIMMERS

A. Manufacturer: Lutron or approved.

B. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches with audible frequency and EMI/RFI suppression filters.

C. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

## 2.4 LIGHTING CONTACTORS

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

1. Square D
2. Siemens
3. General Electric

B. Description: Electrically operated and electrically held.

1. Current Rating for Switching: Listing or rating consistent with type of load served, 30-amp minimum, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide control power transformer, red pilot light and H-O-A switch matching the NEMA type specified for the enclosure.

## 2.5 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26, Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26, Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Division 26, Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables."

## PART 3 - EXECUTION

### 3.1 SENSOR INSTALLATION

A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

### 3.2 DIMMER INSTALLATION

A. Install dimmers within terms of their listing.

B. Install unshared neutral conductors on line and load side of dimmers according to manufacturer's device listing conditions in the written instructions.

### 3.3 WIRING INSTALLATION

A. Wiring Method: Comply with Division 26, Section 26 05 19, "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 3/4 inch.

B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

### 3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26, Section 26 05 33, "Identification." Provide phenolic nameplate on the cover of each lighting contactor enclosure that identifies the circuits controlled and areas served.

### 3.5 COMMISSIONING OF LIGHTING CONTROL DEVICES

A. All lighting controls shall be commissioned to ensure they operate according to the manufacturer's specifications. Prior to commissioning, conduct a pre-commissioning meeting with the Owner and the Engineer to establish the settings for the devices. Provide a commissioning report that provides the following for each room:

1. Lighting control device type and part number.

2. Device settings.

B. Confirmation that devices operate according to the specifications.

3.6 INSTALLED SPARE DEVICES

A. Provide the following spare occupancy sensors including associated raceways and wiring:

| Item | Quantity |
|---|---|
| Dual Technology | 8 |
| Occupancy Sensor Switches | 4 |
| Timer Switches | 1 |

B. Spare devices shall include 75 feet of conduit, faceplates, all require wire, cutting, patching and painting for a complete installation. Location of these units is to be determined by the Owner's representative at the site. The Contractor shall assume that these devices will be installed after all other work is completed. Installation shall occur on an accelerated (night/weekend) schedule. Unused devices are to be turned over to the Owner.

END OF SECTION 260923

SECTION 260943 – NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 SUMMARY

A. The lighting control system specified in this section shall provide time-based, sensor-based (occupancy), and manual lighting control for the interior fixtures.

B. The system shall be capable of turning lighting loads on/off as well as dimming lights. Luminaires shall be configured for continuous dimming.

C. All system devices shall be networked together enabling digital communication. Each luminaire shall be individually addressed, unless otherwise noted.

D. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost.

E. The system architecture shall facilitate remote operation via a computer connection.

F. The system shall not require any centrally hardwired switching equipment.

1.2 SUBMITTALS

A. Product Datasheets (general device descriptions, dimensions, wiring details, nomenclature)

B. Riser Diagrams – typical per room type (detailed drawings showing device interconnectivity of devices)

C. Shop Drawings – Plans based on lighting sheets locating any and all devices required for a fully operational lighting control system.

D. Other Diagrams – as needed for special operation or interaction with other system(s)

E. Example Contractor Startup/Commissioning Worksheet – must be completed prior to factory start-up

F. Hardware and Software Operation Manuals

G. Other operational descriptions as needed

1.3 QUALITY ASSURANCE

A. All steps in sensor manufacturing process shall occur in the USA; including population of all electronic components on circuit boards, soldering, programming, wiring, and housing.

B. All components and the manufacturing facility where product was manufactured must be ROHS compliant.

C. In high humidity or cold environments, the sensors shall be conformably coated and rated for condensing humidity and -40 degree Fahrenheit (and Celsius) operation.

D. All applicable products must be UL / CUL Listed or other acceptable national testing organization.

1.4 COORDINATION

A. Coordinate lighting control components to form an integrated interconnection of compatible components.

B. Coordinate lighting controls with BAS (if necessary) either through IP based intercommunication of system or hardwired auxiliary relay outputs.

C. The installing contractor shall be responsible for a complete and functional system in accordance with all applicable local and national codes.

1.5 WARRANTY

A. All devices in the lighting control system shall have a 5 year manufacturer's warranty.

B. Warranty period shall begin after the completion of the installation and the system's start-up and training, the point at which the system owner receives beneficial use of the control system or 1 year after shipment from the manufacturer, whichever occurs first.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers:

1. Acuity nLight
2. Legrand Wattstopper
3. NX Lighting Controls
4. Cooper Lighting Wavelinx
5. Approved Equal

2.2 SYSTEM/NETWORK REQUIREMENTS

A. Provide enhanced digital lighting controls complying with 2015 IECC for interior lighting. Each luminaire shall have individually addressable embedded controls installed by the manufacturer. An exception is not more than 10% of the total interior lighting power located in non-public support spaces such as mechanical/electrical, custodial, and storage rooms.

B. System shall have an architecture that is based upon three main concepts; 1) intelligent lighting control devices 2) standalone lighting control zones 3) network backbone for remote or time based operation.

C. Intelligent lighting control devices shall consist of one or more basic lighting control components; occupancy sensors, photocell sensors, relays, dimming outputs, manual switch stations, and manual dimming stations. Combining one or more of these components into a single device enclosure should be permissible so as to minimize overall device count of system.

D. System must interface directly with intelligent LED luminaires such that only CAT-5 cabling is required to interconnect luminaires with control components such as sensors and switches (see Networked LED Luminaire section)

E. Intelligent lighting control devices shall communicate digitally, require <4 mA of current to function (Graphic wall stations excluded), and possess RJ-45 style connectors.

F. Lighting control zones shall consist of one or more intelligent lighting control components, be capable of stand-alone operation, and be capable of being connected to a higher level network backbone.

G. Devices within a lighting control zone shall be connected with CAT-5e low voltage cabling in any order.

H. Lighting control zone shall be capable of automatically configuring itself for default operation without any start-up labor required.

I. Individual lighting zones must continue to provide a user defined default level of lighting control in the event of a system communication failure with the backbone network or the management software becoming unavailable.

J. Power for devices within a lighting control zone shall come from either resident devices already present for switching (relay device) or dimming purposes, or from the network backbone. Standalone “bus power supplies” shall not be required in all cases.

K. All switching and dimming for a specific lighting zone shall take place within the devices located in the zone itself (i.e. not in a remotely located devices such as panels) to facilitate system robustness and minimize wiring requirements. Specific applications that require centralized or remote switching shall be capable of being accommodated.

L. System shall have one or more primary wall mounted network control “gateway” devices that are capable of accessing and controlling connected system devices and linking into an Ethernet LAN.

M. System shall use “bridge” devices that route communication and distribute power for up to 8 directly connected lighting zones together for purposes of decreasing system wiring requirements.

N. System shall have a web-based software management program that enables remote system control, status monitoring, and creation of lighting control profiles.

O. The digital lighting control system shall have the following capabilities:

1. Scheduling and illumination levels of individual luminaires and groups of luminaires are capable of being reconfigured through the system.
2. Load shedding.

3. In open and enclosed offices, the illumination level of luminaires are configured to be individually adjusted by occupants.
4. Occupancy sensors and daylight responsive controls are capable of being reconfigured through the system.

P. Individual lighting zones shall be capable of being segmented into several “local” channels of occupancy, photocell, and switch functionality for more advanced configurations and sequences of operation.

Q. Devices located in different lighting zones shall be able to communicate occupancy, photocell, and switch information via wired backbone.

R. System shall be capable of operating a lighting control zone according to several sequences of operation. System shall be able to change a spaces sequence of operation according to a time schedule so as to enable customized time-of-day, day-of-week utilization of a space. Note operating modes should be utilized only in manners consistent with local energy codes.

1. Auto-On / Auto-Off (via occupancy sensors)

    a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
    b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
    c. Pressing a switch will turn lights off. The lights will remain off regardless of occupancy until switch is pressed again, restoring the sensor to Automatic On functionality.

2. Manual-On / Auto-Off (also called Semi-Automatic)

    a. Pushing a switch will turn lights on.
    b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.

3. Manual-On to Auto-On/Auto-Off

    a. Pushing a switch will turn lights on.
    b. After initial lights on, zones with occupancy and/or photocell sensors turn lights on/off according to occupancy/vacancy and/or daylight conditions.
    c. Sequence can be reset via scheduled (ex. daily each morning) events

4. Auto-to-Override On

    a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
    b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
    c. Sequence can be reset via scheduled (ex. daily each morning) events

5. Manual-to-Override On

    a. Pushing a switch will turn lights on.

b. Zone lighting then goes into an override on state for a set amount of time or until the next time event returns the lighting to an auto-off style of control.
c. Sequence can be reset via scheduled (ex. daily each morning) events

6. Auto On / Predictive Off

a. Zones with occupancy sensors automatically turn lights on when occupant is detected.
b. Zones with occupancy and/or photocell sensors turn lights off when vacancy or sufficient daylight is detected.
c. If switch is pressed, lights turn off and a short "exit timer" begins. After timer expires, sensor scans the room to detect whether occupant is still present. If no occupancy is detected, zone returns to auto-on. If occupancy is detected, lights must be turned on via the switch.

7. Multi-Level Operation (multiple lighting levels per manual button press)

a. Operating mode designed specifically for bi-level applications
b. Enables the user to cycle through the up to four potential on/off lighting states using only a single button.
c. Eliminates user confusion as to which of two buttons controls which load
d. Three different transition sequences are available in order to comply with energy codes or user preference)
e. Mode available as a setting on all devices that have single manual on/off switch.
f. Depending on the sequence selected, every button push steps through relays states according to below table
g. In addition to achieving bi-level lighting control by switching loads with relays, the ability to command dimming outputs to "step" in a sequence that achieves bi-level operation is present.

S. A taskbar style desktop application shall be available for personal lighting control.

T. An application that runs on "smart" handheld devices (such as an Apple® IPhone®) shall be available for personal lighting control.

U. Control software shall enable logging of system performance data and presenting useful information in a web-based graphical format and downloadable to .CSV files.

V. Control software shall enable integration with a BMS via BACnet IP.

W. System shall provide the option of having pre-terminated plenum rated CAT-5e cabling supplied with hardware.

## 2.3 INDIVIDUAL DEVICE SPECIFICATIONS

A. Control Module (Gateway)

1. Control module shall be a device that facilitates communication and time-based control of downstream network devices and linking into an Ethernet.

2. Devices shall have a user interface that is capable of wall mounting, powered by low voltage, and have a touch screen.
3. Control device shall have three RJ-45 ports for connection to other backbone devices (bridges) or directly to lighting control devices.
4. Device shall automatically detect all devices downstream of it.
5. Device shall have a standard and astronomical internal time clock.
6. Device shall have one RJ-45 10/100 BaseT Ethernet connection.
7. Device shall have a USB port
8. Each control gateway device shall be capable of linking 1500 devices to the management software.
9. Device shall be capable of using a dedicated or DHCP assigned IP address.

B. Networked System Occupancy Sensors

1. Occupancy sensors system shall sense the presence of human activity within the desired space and fully control the on/off function of the lights.
2. Sensors shall utilize passive infrared (PIR) technology, which detects occupant motion, to initially turn lights on from an off state; thus preventing false on conditions.
3. For applications where a second method of sensing is necessary to adequately detect maintained occupancy (such as in rooms with obstructions), a sensor with an additional "dual" technology shall be used.
4. Dual technology sensors shall have one of its two technologies not require motion to detect occupancy. Acceptable dual technology includes PIR/Microphonics (also known as Passive Dual Technology or PDT) which both looks for occupant motion and listens for sounds indicating occupants.
5. All sensing technologies shall be acoustically passive meaning they do not transmit sounds waves of any frequency (for example in the Ultrasonic range), as these technologies have the potential for interference with other electronic devices within the space. Acceptable detection technologies include Passive Infrared (PIR), and/or Microphonics technology.
6. Sensors shall be available with zero, one, or two integrated Class 1 switching relays, and up to one 0-10 VDC dimming output. Sensors shall be capable of switching 120 / 277 / 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor. Relays shall be dry contacts.
7. Sensors shall be available with one or two occupancy "poles", each of which provides a programmable time delay.
8. Sensors shall be available in multiple lens options which are customized for specific applications.
9. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5e low voltage cabling with RJ-45 connectors.
10. All sensors shall have two RJ-45 ports or capable of utilizing a splitter.
11. All sensors shall have the ability to detect when it is not receiving valid communication (via CAT-5e connections) and blink its LED in a pattern to visually indicate of a potential wiring issue
12. Every sensor parameter shall be available and configurable remotely from the software and locally via the device push-button.
13. Sensors shall be able to function together with other sensors in order to provide expanded coverage areas by simply daisy-chain wiring together the units with CAT-5e cabling.
14. Sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements.

15. Wall switch sensors shall recess into single-gang switch box and fit a standard GFI opening.
16. Wall switch sensors must meet NEC grounding requirements by providing a dedicated ground connection and grounding to mounting strap. Line and load wire connections shall be interchangeable. Sensor shall not allow current to pass to the load when sensor is in the unoccupied (Off) condition.
17. Wall switch sensors shall have optional features for photocell/daylight override, vandal resistant lens, and low temperature/high humidity operation.
18. Wall switch sensors shall be available in four standard colors (Ivory, White, Light Almond, Gray)
19. Wall switch sensors shall be available with optional raise/lower dimming adjustment controls.
20. Network system shall have sensors that can be embedded into luminaire such that only the lens shows on luminaire face.
21. Embedded sensors shall be capable of both PIR and Dual Technology occupancy detection.
22. Embedded sensors shall have an optional photocell.
23. Network system shall also have ceiling, fixture, recessed, & corner mounted sensors available.
24. Fixture mount sensors shall be capable of powering themselves via a line power feed.
25. Sensors shall have optional features for photocell/daylight override, dimming control, and low temperature/high humidity operation.
26. Sensors with dimming can control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of Class 2 current (typically 40 or more ballasts).
27. Embedded sensors shall have an optional photocell and 0-10 VDC dimming output.

C. Networked System Daylight (Photocell and or Dimming) Sensors

1. Photocell shall provide for an on/off set-point, and a deadband to prevent the artificial light from cycling. Delay shall be incorporated into the photocell to prevent rapid response to passing clouds.
2. Photocell and dimming sensor's set-point and deadband shall be automatically calibrated through the sensor's microprocessor by initiating an "Automatic Set-point Programming" procedure. Min and max dim settings as well as set-point may be manually entered.
3. Deadband setting shall be verified and modified by the sensor automatically every time the lights cycle to accommodate physical changes in the space (i.e., furniture layouts, lamp depreciation, or lamp outages).
4. Dimming sensors shall control 0 to 10 VDC dimmable ballasts by sinking up to 20 mA of class 2 current (typically 40 or more ballasts).
5. Photocell and dimming sensors shall be equipped with an automatic override for 100 hour burn-in of lamps. This feature must be available at any time for lamp replacements. (Note: This function should be performed prior to any dimming of the lamps including the "auto set-point" setting.)
6. Combination units that have all features of on/off photocell and dimming sensors shall also be available.
7. A dual zone option shall be available for On/Off Photocell, Automatic Dimming Control Photocell, or Combination units. The second zone shall be capable of being controlled as an "offset" from the primary zone.

8. Line voltage versions of the above described photocell and combination photocell/dimming sensors shall be capable of switching both 120 VAC, 277 VAC, and 347 VAC. Load ratings shall be 800 W @ 120 VAC, 1200 W @ 277 VAC, 1500 W @ 347 VAC, and ¼ HP motor load. Relays shall be dry contacts.
9. No more than eight luminaires within a daylight zone shall be controlled by a single daylight responsive control device.

D. Networked System Power (Relay) Packs

1. Power Pack shall incorporate one or more Class 1 relays and contribute low voltage power to the rest of the system. Secondary Packs shall incorporate the relay(s), shall have an optional 2nd relay, 0-10 VDC dimming output, or line voltage dimming output, but shall not be required to contribute system power. Power Supplies shall provide system power only, but are not required to switch line voltage circuit. Auxiliary Relay Packs shall switch low voltage circuits only.
2. Power Packs shall accept 120 or 277 VAC (or optionally 347 VAC), be plenum rated, and provide Class 2 power to the system.
3. All devices shall have two RJ-45 ports.
4. Every Power Pack parameter shall be available and configurable remotely from the software and locally via the device push-button or remote.
5. Power Pack shall securely mount to junction location through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads. Note: UL Listing under Energy Management or Industrial Control Equipment automatically meets this requirement, whereas Appliance Control Listing does not meet this safety requirement.
6. When required by local code, Power Pack must install inside standard electrical enclosure and provide UL recognized support to junction box. All Class 1 wiring is to pass through chase nipple into adjacent junction box without any exposure of wire leads.
7. Power Packs and Power Supplies shall be available that are WiFi enabled.
8. Power (Secondary) Packs shall be available that provide up to 16 Amp switching of all lighting load types.
9. Power (Secondary) Packs shall be available that provide up to 5 Amps switching of all lighting load types as well as 0-10 VDC dimming or fluorescent ballasts/LED drivers.
10. Specific Secondary Packs shall be available that provide up to 5 Amps of switching as well as 0-10 VDC dimming of fluorescent ballasts/LED drivers.
11. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120 VAC incandescent lighting loads or 120/277 VAC line voltage dimmable fluorescent ballasts (2-wire and 3-wire versions).
12. Specific Secondary Packs shall be available that provide up to 5 Amps of switching and can dim 120/277 VAC magnetic low voltage transformers.
13. Specific Secondary Packs shall be available that provide up to 4 Amps of switching and can dim 120 VAC electronic low voltage transformers.
14. Specific Secondary Packs shall be available that provide up to 5 Amps of switching of dual phase (208/240/480 VAC) lighting loads.
15. Specific Secondary Packs shall be available that require a manual switch signal (via a networked Wall Station) in order to close its relay.
16. Specific Power/Secondary Packs shall be available that are UL924 listed for switching of Emergency Power circuits.
17. Specific Secondary Packs shall be available that control louver/damper motors for skylights.

18. Specific Secondary Packs shall be available that provide a pulse on/pulse off signal for purposes of controlling shade systems via relay inputs.

E. Networked System Relay & Dimming Panels

1. Panel shall incorporate up to 4 normally closed latching relays capable of switching 120/277 VAC or up to 2 Dual Phase relays capable of switching 208/240/480 VAC loads.
2. Relays shall be rated to switch up to a 30A ballast load at 277 VAC.
3. Panel shall provide one 0-10VDC dimming output paired with each relay.
4. Panel shall power itself from an integrated 120/277 VAC supply.
5. Panel shall be capable of operating as either two networked devices or as one.
6. Panel shall supply current limited low voltage power to other networked devices connected via CAT-5.
7. Panel shall provide auxiliary low voltage device power connected wired directly to a dedicated terminal connection.

F. Networked Auxiliary Input / Output (I/O) Devices

1. Devices shall be plenum rated and be inline wired, screw mountable, or have an extended chase nipple for mounting to a ½" knockout.
2. Devices shall have two RJ-45 ports.
3. Communication and low voltage power shall be delivered to each device via standard CAT-5e low voltage cabling with RJ-45 connectors.
4. Specific I/O devices shall have a dimming control output that can control 0-10 VDC dimmable ballasts or LED drivers by sinking up to 20 mA of current (typically 40 or more ballasts).
5. Specific I/O devices shall have an input that read a 0-10 VDC signal from an external device.
6. Specific I/O devices shall have a switch input that can interface with either a maintained or momentary switch and run a switch event, run a local/remote control profile, or raise/lower a dimming output.
7. Specific I/O devices shall sense state of low voltage outdoor photocells.
8. Specific I/O devices shall enable RS-232 communication between lighting control system and Touch Screen based A/V control systems.
9. Specific I/O devices shall sense.

G. Networked System Wall Switches & Dimmers

1. Devices shall recess into single-gang switch box and fit a standard GFI opening.
2. Devices shall be available with zero or one integrated Class 1 switching relay.
3. Communication and low voltage power shall be delivered to each device via standard CAT-5 low voltage cabling with RJ-45 connectors.
4. All sensors shall have two RJ-45 ports.
5. All devices shall provide toggle switch control. Dimming control and low temperature/high humidity operation are available options.
6. Devices shall be available in four colors (Ivory, White, Light Almond, Gray).
7. Devices with dimming control outputs can control 0-10 VDC dimmable ballasts by sinking up to 20 mA of current (typically 40 or more ballasts).
8. Devices with capacitive touch buttons shall provide audible user feedback with different sounds for on/off, raise/lower, start-up, and communication offline.
9. Devices with mechanical push-buttons shall provide tactile and LED user feedback.

10. Devices with mechanical push-buttons shall be made available with custom button labeling
11. Devices with a single on button shall be capable of selecting all possible lighting combinations for a bi-level lighting zone such that the user confusion as to which of two buttons (as is present in multi-button scenarios) controls which load is eliminated.

H. Networked System Graphic Wall Station

1. Device shall have a 3.5" full color touch screen for selecting up to 8 programmable lighting control presets or acting as up to 16 on/off/dim control switches.
2. Device shall enable configuration of lighting presets, switched, and dimmers via password protected setup screens.
3. Device shall enable user supplied .jpg screen saver image to be uploaded.
4. Device shall surface mount to single-gang switch box.
5. Device shall have a micro-USB style connector for local computer connectivity.
6. Device shall have two RJ-45 ports for communication.
7. Device shall have two to four buttons for selecting programmable lighting control profiles or acting as on/off switches.
8. Device shall recess into single-gang switch box and fit a standard GFI opening.
9. Devices shall provide LED user feedback.
10. Communication and Class 2 low voltage power shall be delivered to each device via standard CAT-5e low voltage cabling with RJ-45 connectors.
11. All sensors shall have two RJ-45 ports.
12. Device shall be capable of reprogramming other devices in its zone so as to implement user selected lighting scene.
13. Device shall be capable of selecting a lighting profile be run by the system's upstream Gateway so as to implement selected lighting profile across multiple zones (and not just its local zone).
14. Device shall have LEDs indicating current selection.

I. Communication Bridges

1. Device shall surface mount to a standard 4" x 4" square junction box.
2. Device shall have 8 RJ-45 ports.
3. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to Control Gateway.
4. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply or delivered via a CAT-5e cabled connection.
5. Device shall be careful of redistributing power from its local supply and connect lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.

## 2.4 LIGHTING CONTROL PROFILES

A. Changes to the operation of the system shall be capable of being made in real-time or scheduled via lighting control profiles. These profiles are outlines of settings that direct how a collection of devices function for a defined time period.

B. Lighting control profiles shall be capable of being created and applied to a single device, zone of devices, or customized group of zones.

C. All relays and dimming outputs shall be capable of being scheduled to track or ignore information regarding occupancy, daylight, and local user switches via lighting control profiles.

D. Every device parameter (e.g. sensor time delay and photocell set-point) shall be configurable via a lighting control profile.

E. All lighting control profiles shall be stored on the network control gateway device and on the software's host server.

F. Lighting control profiles shall be capable of being scheduled to run according to the following calendar options: start date/hour/minute, end date/hour/minute, and sunrise/sunset +/- timed offsets.

G. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.

H. Daylight savings time adjustments shall be capable of being performed automatically, if desired.

I. Lighting control profile schedules shall be capable of being given the following recurrence settings: daily, weekday, weekend, weekly, monthly, and yearly.

J. Software shall provide a graphical tool for easily viewing scheduled lighting control profiles.

## 2.5 MANAGEMENT SOFTWARE

A. Every device parameter (e.g. sensor time delay and photocell set-point) shall be available and configurable remotely from the software

B. The following status monitoring information shall be made available from the software for all devices for which it is applicable: current occupancy status, current PIR Status, current Microphonics Status, remaining occupancy time delay(s), current photocell reading, current photocell inhibiting state, photocell transitions time remaining, current dim level, device temperature, and device relay state(s).

C. The following device identification information shall be made available from the software: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.

D. A printable network inventory report shall be available via the software.

E. A printable report detailing all system profiles shall be available via the software.

F. Software shall require all users to login with a User Name and Password.

G. Software shall provide at least three permission levels for users.

H. All sensitive stored information and privileged communication by the software shall be encrypted.

I. All device firmware and system software updates must be available for automatic download and installation via the internet.

J. Software shall be capable of managing systems interconnected via a WAN (wide area network)

## 2.6 BMS COMPATIBILITY

A. System shall provide a BACnet IP gateway as a downloadable software plug-in to its management software. No additional hardware shall be required.

B. BACnet IP gateway software shall communicate information gathered by networked system to other building management systems.

C. BACnet IP gateway software shall translate and forward lighting relay and other select control commands from BMS system to networked control devices.

## 2.7 SYSTEM ENERGY ANALYSIS & REPORTING SOFTWARE

A. System shall be capable of reporting lighting system events and performance data back to the management software for display and analysis.

B. Intuitive graphical screens shall be displayed in order to facilitate simple viewing of system energy performance.

C. An “Energy Scorecard” shall be display that shows calculated energy savings in dollars, KWHr, or $CO_2$.

D. Software shall calculate the allocation of energy savings to different control measures (occupancy sensors, photocells, manual switching, etc).

E. Energy savings data shall be calculated for the system as a whole or for individual zones.

F. A time scaled graph showing all relay transitions shall be presented.

G. A time scaled graph showing a zones occupancy time delay shall be presented.

H. A time scaled graph showing the total light level shall be presented.

I. User shall be able to customize the baseline run-time hours for a space.

J. User shall be able to customize up to four time-of-day billing rates and schedules.

K. Data shall be made available via a .CSV file.

## 2.8 START-UP & SUPPORT FEATURES

A. To facilitate start-up, all devices daisy-chained together (using CAT-5e) shall automatically be grouped together into a functional lighting control zone.

B. All lighting control zones shall be able to function according to default settings once adequate power is applied and before any system software is installed.

C. Once software is installed, system shall be able to auto-discover all system devices without requiring any commissioning.

D. All system devices shall be capable of being given user defined names.

E. All devices within the network shall be able to have their firmware reprogrammed remotely and without being physically uninstalled for purposes of upgrading functionality at a later date.

F. All sensor devices shall have the ability to detect improper communication wiring and blink its LED in a specific cadence as to alert installation/startup personnel.

## PART 3 - EXECUTION

### 3.1 INSTALLATION

A. All equipment shall be installed in accordance with manufacturer's installation instructions and in compliance with all applicable local and national codes and requirements.

B. Provide complete installation of system in accordance with Contract Documents.

C. Provide room by room documentation on the commissioning of the system including by not limited to the following:

1. Sequence of operations
2. Device settings
3. Load parameters
4. Schedules

### 3.2 FACTORY COMMISSIONING

A. Upon completion of the installation, the system shall be commissioned by the manufacturer's factory authorized representative who will verify a complete fully functional system.

B. The electrical contractor shall provide both the manufacturer and the electrical engineer with ten working days written notice of the system startup and adjustment date.

C. Upon completion of the system commissioning, the factory-authorized technician shall provide the proper training to the owner's personnel on the adjustment and maintenance of the system.

### 3.3 PROJECT COMMISSIONING

A. The equipment and systems referenced in this section are to be commissioned per General Commissioning Requirements and Commissioning of Electrical Systems. The contractor has specific responsibilities for scheduling, coordination, startup, test development, testing and documentation. Coordinate all commissioning activities with the Commissioning Authority.

3.4 IDENTIFICATION

A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Identify controlled circuits in lighting contactors.

C. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.

D. Label time switches and contactors with a unique designation.

END OF SECTION 260943

SECTION 262726 – WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED REQUIREMENTS

A. Drawings and general requirements of the Contract, amendments and general provisions, apply to this Section.

1.2 SCOPE

A. Provide all wiring devices complete with device plates shown on the drawings or specified within the specifications.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Bryant, Cooper Wiring Devices, Hubbell, P & S, Leviton, of approved equal. All part numbers refer to Hubbell to establish minimum standards for quality and performance.

2.2 GENERAL

A. All devices shall be specification grade. Color shall be ivory for normal services and red for all services automatically fed from the emergency generator.

2.3 SWITCHES

A. Single-Pole: 20-ampere, 120/277-volt, Hubbell No. 1221 Series.

B. Three-Way: 20-ampere, 120/277-volt, Hubbell No. 1223 Series.

C. Locking: 20-ampere, 120/277-volt, Hubbell No. 1221L (1-pole) Series or No. 1223L (3-way) series. Provide two keys with each switch. Cover plate shall be stainless steel with on/off labels.

2.4 RECEPTACLES

A. Duplex Receptacles, Specification-Grade: 20-ampere, 125-volt, 2-pole, 3-wire grounding, NEMA Type 5-20R Hubbell No. CR5362I (Ivory Color).

B. Duplex Receptacles originating from surge protected panels, Specification-Grade: 20-ampere, 125-volts, 3-wire grounding. NEMA Type 5-20R Hubbell No. CR5362GY (Gray Color).

C. Duplex Receptacles, Safety Type, Specification-Grade: Safety-type, specification-grade device, rated at 20-ampere, 125-volt, grounded type, NEMA Type 5-20R; Hubbell No. SG-63 or approved equal. Receptacles must be capable of accepting double bladed plugs without ground pin.

D. Receptacles for switched curcuits shall be capble of being sepearted so that the top is switched separately from the bottom.

E. Ground Fault Circuit Interrupter (GFCI) Receptacles: Specification grade, weather resistant, 20-ampere, 125-volt, Class A, 5-milliampere sensitivity, standard or feed-through model and as shown on the drawings. Hubbell No. GF 5262 or approved equal.

F. Faceless GFI Module: Specification-grade, 20 ampere, 125 volt, Class A, 5 milliampere sensitivity. Hubbell No. GF53501A or approved equal.

G. Weatherproof Receptacles: Weather-resistant, GFCI-type receptacle with in-use, weatherproof, low-profile, lockable, diecast metallic alloy cover. Greenfield No. WIUVPS or approved equal.

H. Special Receptacles: For other special receptacles, see drawings.

I. Cord Caps: Cord caps on all cords shall be plastic insulated type.

## 2.5 DEVICE PLATES

A. Prohibited materials.

1. Sectional plates shall not be utilized.

B. All devices shall be equipped with stainless steel 0.04” thick with #302 satin finish, except for audiovisual devices which may be plastic.

C. All junction boxes in finished areas shall be provided with stainless steel plates.

## 2.6 INSTALLATION

A. Install two or more wiring devices shown in one location under a common plate except when outlets are of a different voltages such as telephone and duplex receptacles. Install plates with all edges in continuous contact with finished wall surfaces. Install plates vertically with alignment tolerance of 1/16 inch. Sectional plates are not permitted. No more than one device shall be installed in a single-gang position.

B. Wiring: Branch circuit conductors shall be terminated either in side of or in back of specification-grade devices with screw clamped terminations. Spring-type pressure connections not approved. Wiring devices are not to be used for maintaining circuit continuity. Wiring devices are not to be used for maintaining circuit continuity. Removal of wiring device shall not effect downstream devices.

C. Barrel type key switch shall be used to control lighting in corridors, gyms, cafeterias and restrooms (not required for single occupant restrooms).

D. Orient receptacles so that ground pin is at bottom or to the right.

E. Outlet height to meet ADA requirements or 16 inches minimum above floor.

F. Attach surface raceway assemblies to wall surface by method recommended by manufacturer for the particular wall construction. Use anchos similar to Powers Poly-toggle, catalog #2305 with 1-1/2" screw minimum.

PART 3 - EXECUTION (NOT USED)

END OF SECTION 262726

SECTION 262813 - FUSES

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. Cartridge fuses rated 600-V ac and less for use in enclosed switches.
2. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches.
3. Spare-fuse cabinets.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components for each type provided as follows:

1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
2. Current-limitation curves for fuses with current-limiting characteristics.

1.4 QUALITY ASSURANCE

A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

B. 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.

C. Comply with NEMA FU 1 for cartridge fuses.

D. Comply with NFPA 70.

E. Comply with UL 248-11 for plug fuses.

1.5 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) more than 100 deg F (38 deg C), apply manufacturer’s ambient temperature adjustment factors to fuse ratings.

## 1.6 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

# PART 2 - PRODUCTS

## 2.1 MANUFACTURERS

A. 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 Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.
5. Or Approved Equal.

## 2.2 CARTRIDGE FUSES

A. Fuse "Class" defines fuse performance category, including interrupting rating. See Editing Instruction No. 2 and "Cartridge Fuses" Article in the Evaluations. Include current rating and class for cartridge fuses either on Drawings or in "Fuse Applications" Article.

B. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

C. General purpose fuses 250V: Type FRNR.

D. General purpose fuses 600V: Type FRSR.

## 2.3 PLUG FUSES

A. Fuse "Type" defines fuse performance category and base types. See Editing Instruction No. 3 and "Plug Fuses" Article in the Evaluations. Include current rating and type designations for plug fuses either on Drawings or in "Fuse Applications" Article.

B. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

## 2.4 PLUG-FUSE ADAPTERS

A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

## 2.5 PLUG FUSE BOX COVER UNITS

A. Box Cover Units: 4” square box cover with plug fuse holder, on/off switch, single receptacle equal to Bussmann SSY.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

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

## 3.2 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK1, time delay.

B. Plug Fuses with box cover units for motor branch circuits 120V less than ½ HP: Plug Fuses: Edison-base type, dual-element time delay. Type T or TL for box cover units.

## 3.3 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

B. Install plug-fuse adapters in Edison-base fuse holders and sockets. Ensure that adapters are irremovable once installed.

## 3.4 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - 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.

B. Specification Section 262813 Fuses

1.2 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Molded-case circuit breakers and switches.
3. Enclosures.

1.3 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed switches shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the specified seismic forces.

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, accessories, and finishes.

1. Enclosure types and details for types other than NEMA 250, Type 1.
2. Current and voltage ratings.
3. Short-circuit current ratings (interrupting and withstand, as appropriate).
4. Include evidence of NRTL listing.

5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches. Include plans, elevations, sections, details, and attachments to other work.

## 1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. 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.

C. Comply with NFPA 70.

## 1.7 COORDINATION

A. Coordinate layout and installation of switches, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. The horsepower of motors and apparatus wattages indicated on the plans are estimated requirements of equipment furnished under other sections of the specifications. All switches shall be of the sizes and capacities to suit the horsepower of the motors and equipment actually furnished.

C. Should equipment substitution result in additional electrical expense, the supplier making the substitution shall be responsible for the additional electrical design and installation expenses incurred by the Division 26 Engineer and Contractor. Prior to rough-in the Division 26 Contractor shall obtain a copy of all approved equipment submittals and verify all equipment connection requirements.

# PART 2 - PRODUCTS

## 2.1 FUSIBLE SWITCHES

A. 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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.
5. Or Approved Equal.

B. Type HD, Heavy Duty, Two or Three Pole, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle in open or closed position with capability to accept three padlocks and interlocked with cover in closed position. HD required for all poly-phase circuits.

C. 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; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.
6. 6. Auxiliary Contact Kit: Two NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open. Provide where specified.

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; labeled for copper and aluminum neutral conductors.
3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
4. Hookstick Handle: Allows use of a hookstick to operate the handle.
5. Lugs: Mechanical type, suitable for number, size, and conductor material.

## 2.2 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Molded-Case Circuit Breaker: NEMA AB 1 with interrupting capacity to meet available fault currents. Provide with the following features and accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style with compression lug kits 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.

B. Molded-Case Switches: Molded-case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating. Provide with the following features and accessories:

1. Lugs: Mechanical style with compression lug kits suitable for number, size, trip ratings, and material of conductors.
2. Application Listing: Type HACR for heating, air-conditioning, and refrigerating equipment.

## 2.3 ENCLOSURES

A. Enclosed Switches: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.

1. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
2. Outdoor Wet Locations: NEMA 250, Type 3R.

# PART 3 - EXECUTION

## 3.1 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches for compliance with installation tolerances and other conditions affecting performance of the Work.

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

## 3.2 INSTALLATION

A. Install individual wall-mounted switches with tops at uniform height unless otherwise indicated.

B. Install fuses in fusible devices.

C. Comply with NECA 1.

## 3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

1. Label each enclosure with engraved metal or laminated-plastic nameplate.

## 3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Engage a factory-authorized service representative to provide technical assistance.
2. Inspect components, assemblies, and equipment installations, including connections.

## 3.5 ADJUSTING

A. Adjust moving parts and operable components to function smoothly and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 265100 - LIGHTING

PART 1 - GENERAL

1.1 OUTLINE OF WORK

A. Furnish and install all lighting luminaires and related accessories as scheduled herein for the portion of the building to have alterations. All luminaire installations shall be complete with lamps specified.

1.2 SUBMITTALS

A. Submit a fixture list for prior approval before the bid date.

B. Product Datasheets (general device descriptions, dimensions, wiring details, nomenclature)

C. Shop Drawings

1.3 RELATED ACCESSORIES

A. Provide frames, hangers, spacers, stems, aligner canopies, auxiliary junction boxes and other hardware as required for a complete installation. Recessed luminaires shall have frames that are compatible with the ceiling systems.

1.4 LABELS

A. Provide UL labels on all luminaires. Lighting luminaires installed in damp or wet locations in interior or exterior areas shall have label "Suitable for Damp Locations" or "Suitable for Wet Locations."

B. All luminaires shall comply with Buy American Act (BAA).

C. Lighting luminaires installed in lab/cleanroom rated locations in interior areas shall have minimum ISO Class 3 certified label. Luminaires shall be closed and gasketed. Luminaires shall have minimum IP65 certified label.

1.5 MANUFACTURERS' CATALOG NUMBERS

A. Catalog series numbers specified represent the type and style of luminaire. The size of luminaire shall correspond with the wattage indicated on the luminaire specification sheets or the actual length of the luminaire as indicated on the electrical drawings.

## 1.6 LED DRIVERS

A. LED Drivers: Operation to be at standard rated voltage of driver, not "over-driven". Comply with UL 1598 and 8750. Test according to IES LM-79 and LM-80.

1. Minimum efficiency: 85% at full load.
2. Minimum operation Ambient Exterior Temperature: - 40 degrees C (- 40 degrees F)
3. Input Voltage: 120 – 277 V (+/- 10%) at 60 Hz
4. Integral short circuit, open circuit, and overload protection
5. Power Factor: >95%
6. Total Harmonic Distortion: < 20%
7. Comply with FCC 47 CFR Part 15

## 1.7 LED SOURCES

A. LED Luminaires shall be in accordance with IES, NFPA, UL, as shown on drawings, and as specified. Where conflicts occur, the most expensive option shall govern, no exceptions.

B. LED Luminaires shall be Reduction of Hazardous Substance (ROHS) – compliant.

C. LED Modules shall include the following features unless otherwise indicated:

D. Comply with IES LM-79, LM-80, and LM-82 requirements

E. Color Rendering Index and Color Temperature as specified in Luminaire Schedule.

F. Minimum rated life: 50,000+ hours per IES L70 definition or as specified in Luminaire Schedule.

G. Light Output Lumens as specified in Luminaire Schedule.

H. LED Exterior Luminaires: Shall be Tenant approved.

## 1.8 LUMINAIRE SUPPORT

A. Safety Hangers: Provide four No. 12 gauge slack wire safety hangers on diagonal corners of each recessed or surface mounted LED luminaire installed on this project. Secure wires to structure above, independent of ceiling system.

## 1.9 LUMINAIRE ACCESSORIES

A. Luminaire Lenses: All plastic luminaire lenses are to be pattern 12, minimum 1/8-inch thick, and 100 percent virgin acrylic plastic unless specified otherwise. Refer to Luminaire Schedule.

B. Luminaire Lenses in lab and/or cleanrooms: All plastic luminaire lenses are to be white frosted polycarbonate and minimum 1/8-inch thick. Refer to Luminaire Schedule.

C. Luminaire Hanging and Mounting Accessories: The Electrical Contractor shall provide all necessary hanging or mounting devices for all luminaires and shall be responsible for checking the type needed for various ceiling conditions. Plaster rings shall be provided where required.

D. Pre-manufactured Fixture Whips: Fixture whips assembled at the factory may be used to connect recessed light fixtures in accessible ceilings.

E. Dimming and Embedded Controls: Luminaires shall have provisions for being continuously dimmed and individually addressed. An exception may be made for a group of luminaires contributing a combined 10% or less of the total installed lighting power in the building.

1.10 PROPER LIGHTING LUMINAIRE TYPES

A. Before ordering lighting luminaires, the Electrical Contractor shall be responsible for verifying and coordinating the ceiling systems and lighting luminaire frame requirements as well as the proper ballast voltage.

B. All hinged doors to have aluminum or steel frame with regressed lens design unless specified otherwise. Ridges on lens shall be installed towards the interior of the luminaire housing to reduce the regressed lens surface area. In the clean room environments, luminaires shall be closed and gasketed and sealed with silicone or approved to prevent contamination from entering the luminaire.

C. Provide flexible conduit pigtail and outlet box for each luminaire where installed in accessible suspended ceilings, unless otherwise noted.

D. The luminaire type symbols indicated on the drawings are intended to show the type of luminaire in that particular room or general area. Each individual lighting luminaire shown on the drawings does not necessarily have a luminaire type symbol shown adjacent to it.

1.11 TRADEMARK OR MONOGRAMS

A. There shall be no visible trademarks or monograms on the lighting luminaires.

1.12 LUMINAIRE CONTINUITY

A. All LED luminaires of the same general category (i.e., 1x2's, 1x4's, 2x2's, 2x4's, 4x4's) shall be of same manufacture and series to ensure that all lenses and trims match and are compatible in appearance.

1.13 LOCKING CLIPS

A. Electrical Contractor is to provide and install four locking clips per luminaire for all LED luminaires installed into exposed T-bar ceiling suspension systems. The locking clip is to be attached to the luminaire with a sheet metal screw or similar and secured to the main or supporting T-bar runner to guarantee a secure installation.

1.14 SURFACE MOUNTED LUMINAIRES

A. Provide surface mounted LED luminaires with UL approval for direct mounting on the various ceilings used. Where mounted on lay-in ceilings, support luminaires by at least two positive devices which surround the ceiling runner, and which are supported from the structure above by a No. 12 gauge wire. Spring clips or clamps that connect only to the runner are not acceptable.

1.15 FIRE-RATED ENCLOSURES

A. The Electrical Contractor shall provide 5/8" plasterboard minimum, taped box enclosures for all recessed luminaires in 1- or 2-hour fire-rated ceilings, as required by local building or fire codes. Enclosure to provide minimum 3" air space around luminaire. Electrical Contractor to verify with the Architect areas where this provision is applicable.

PART 2 - PRODUCTS

2.1 LUMINAIRE TYPES

A. Refer to Luminaire Schedule on the drawings.

2.2 OCCUPANCY SENSORS

A. Dual Technology: Provide dual technology (infrared/ultrasonic) occupancy sensors in each room as noted on the drawings. Switch near door of each room is to provide Off-Auto control. When the switch is in the automatic position the occupancy sensors shall turn lights "on" when people are detected within the room. Provide isolated relay output which closes upon sensing occupancy within the room. Wattstopper or approved.

B. Provide auxiliary dry contacts for remote monitoring as indicated on the drawings.

C. Provide power packs as required for the occupancy sensor control system.

D. Provide eight spare occupancy sensors, four spare power packs and four spare slave packs.

PART 3 - EXECUTION

3.1 INSTALLATION OF LUMINAIRES

A. All luminaires shall be installed exactly level, straight and secure. Ceiling luminaires shall be tight to ceiling.

B. Luminaires shall be installed per manufacturer’s recommendations outlined on the installation instructions. A copy of each luminaire types installation instructions shall be maintained and included in the Operations and Maintenance Manual.

C. Contractor shall not install luminaire lenses, diffusers, or parabolic louvers on luminaires until general construction work is complete, including painting. Dirty lenses, diffusers, or louvers shall be removed, washed and rinsed as recommended by luminaire manufacturer.

## 3.2 LUMINAIRE SUPPORT

A. Where luminaires are located so that they cannot be supported by ceiling framing members, the Contractor shall provide additional framing or header bars in ceiling construction as required to support luminaires. Material for luminaire support shall match the ceiling framing material. Luminaires shall be secured to floor slab above or roof structure with a proper hanging device such as lag screw or lag bolt with lead expansion anchor, cinch anchor or stud to support the luminaire plus 100 lbs. at each support. Nails, T-bar clamps or similar fasteners are not approved for lighting luminaire support.

## 3.3 MOUNTING HEIGHTS OF WALL- AND PENDANT-MOUNTED LUMINAIRES

A. Mounting heights of pendant-mounted luminaires shown on plans or in specifications shall be to the bottom of the luminaire. Mounting heights of the wall-mounted luminaires shall be to the center of the outlet box unless otherwise noted.

## 3.4 PENDANT-MOUNTED LUMINAIRES IN CONFLICT WITH DUCTS AND PIPING

A. Electrical Contractor shall coordinate the location and mounting heights of the lighting luminaires in mechanical rooms with the available space left between the various ducts and piping. Any adverse situation shall be resolved as directed by the Architect.

## 3.5 LUMINAIRES IN ACCESSIBLE TYPE SUSPENDED CEILINGS

A. If clearance above T-bar system is too restricted to "tip-in" luminaire, the Electrical Contractor shall coordinate with ceiling installer by leaving one cross T-bar off until the cross T-bar may be fitted into place. LED luminaires installed in hidden-spline type ceilings shall have supporting channels installed by Ceiling Contractor to adequately support the luminaire without providing additional hangers from the structure above the suspended ceiling.

## 3.6 LUMINAIRE SWITCHING

A. Lighting luminaires shall be switched as shown on electrical drawings.

END OF SECTION 265100