PROJECT MANUAL

UMD Solomons Island - Bernie Fowler Lab Roof Replacement

Project No: MD19-10.00

146 Williams Street
Solomons, Maryland 20688

PREPARED FOR:

UNIVERSITY OF MARYLAND
Center for Environmental Science

Construction Documents
May 19, 2023

WALDONSTUDIO ARCHITECTS

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NOT APPLICABLE

SECTION 011000 - SUMMARY

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Project information.
2. Work covered by Contract Documents.
3. Access to site.
4. Coordination with occupants.
5. Work restrictions.
6. Specification and Drawing conventions.
7. Miscellaneous provisions.

B. Related Requirements:

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

1.3 PROJECT INFORMATION

A. Project Identification: UMCES Bernie Fowler Laboratory Roof Replacement.

1. Project Location: 146 Williams Street, Solomons, Maryland 20688.

B. Owner: University of Maryland Center for Environmental Science.

1. Owner's Representative: Stacy Hutchinson.

C. Architect: Waldon Studio.

D. Architect's Consultants: Architect has retained the following design professionals who have prepared designated portions of the Contract Documents:

1. Mechanical and Electrical: RMF Engineering.
2. Roofing: Gale Associates

E. Web-Based Project Software: Project software administered by Architect will be used for purposes of managing communication and documents during the construction stage.

1. See Section 013100 "Project Management and Coordination." for requirements for establishing using web-based Project software.

1.4 WORK COVERED BY CONTRACT DOCUMENTS

A. The Work of Project is defined by the Contract Documents and consists of the following:

1. The project consists of replacement of the low-slope roofing system on the Bernie Fowler Laboratory building. In conjunction with the roof replacment, four air handlers will be replaced. and other Work indicated in the Contract Documents.

B. Type of Contract:

1. Project will be constructed under a single prime contract.

1.5 ACCESS TO SITE

A. General: Contractor shall have full use of Project site for construction operations during construction period. Contractor's use of Project site is limited only by Owner's right to perform work or to retain other contractors on portions of Project.

B. Use of Site: Limit use of Project site to Work in areas indicated. Do not disturb portions of Project site beyond areas in which the Work is indicated.

1. Limits: Confine construction operations to lareas adjacent to the building and within the area of work on the interior/ roof.
2. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

C. Condition of Existing Building: Maintain portions of existing building affected by construction operations in a weathertight condition throughout construction period. Repair damage caused by construction operations.

D. 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.

1.6 COORDINATION WITH OCCUPANTS

A. Partial Owner Occupancy: Owner will occupy the campus during entire construction period, with the exception of areas under construction. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's operations. Maintain existing exits unless otherwise indicated.

1. Maintain access to existing walkways, corridors, and other adjacent occupied or used facilities. Do not close or obstruct walkways, corridors, or other occupied or used facilities without written permission from Owner and authorities having jurisdiction.
2. Provide not less than 72 hours' notice to Owner of activities that will affect Owner's operations.

1.7 WORK RESTRICTIONS

A. Work Restrictions, General: Comply with restrictions on construction operations.

1. Comply with limitations on use of public streets and with other requirements of authorities having jurisdiction.

B. On-Site Work Hours: Limit work in the existing building to normal business working hours of 7:00 a.m. to 700 p.m., Monday through Friday, unless otherwise indicated.

1. Weekend Hours: Insert restrictions on times permitted for weekend work.
2. Early Morning Hours: All weekend work must be scheduled with Owner 48 hours in advance..
3. Hours for Utility Shutdowns: Utility shutdowns must be scheduled with Owner 48 hours in advance..
4. Hours for Any Noisy Activity: Comply with Calvert County Noise Ordinance. Noise Ordinance restricts noise from 10:00 p.m. to 7:00 a.m.

C. Existing Utility Interruptions:

1. Notify Owner not less than two days in advance of proposed utility interruptions.
2. Obtain Owner's written permission before proceeding with utility interruptions.

3. Noise, Vibration, and Odors: Notify Owner not less than two days in advance of proposed disruptive operations.
4. Obtain Owner's written permission before proceeding with disruptive operations.

D. Nonsmoking Building: Smoking is prohibited on all property owned by the State of Maryland.

E. Restricted Substances: Use of tobacco products and other controlled substances on Project site is not permitted.

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

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

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

1.8 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. Specification requirements are to be performed by Contractor unless specifically stated otherwise.

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

C. Drawing Coordination: Requirements for materials and products identified on Drawings are described in detail in the Specifications. One or more of the following are used on Drawings to identify materials and products:

1. Terminology: Materials and products are identified by the typical generic terms used in the individual Specifications Sections.
2. Abbreviations: Materials and products are identified by abbreviations published as part of the U.S. National CAD Standard and scheduled on Drawings.
3. Keynoting: Materials and products are identified by reference keynotes referencing Specification Section numbers found in this Project Manual.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 011000

SECTION 012100 - ALLOWANCES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements governing allowances.

B. Types of allowances include the following:

1. Lump-sum allowances.
2. Unit-cost allowances.

C. Related Requirements:

1. Section 014000 "Quality Requirements" for procedures governing the use of allowances for field testing by an independent testing agency.

1.3 DEFINITIONS

A. Allowance is a quantity of work or dollar amount established in lieu of additional requirements, used to defer selection of actual materials and equipment to a later date when direction will be provided to Contractor. If necessary, additional requirements will be issued by Change Order.

1.4 SELECTION AND PURCHASE

A. At the earliest practical date after award of the Contract, advise Architect of the date when final selection, or purchase and delivery, of each product or system described by an allowance must be completed by the Owner to avoid delaying the Work.

B. At Architect's request, obtain proposals for each allowance for use in making final selections. Include recommendations that are relevant to performing the Work.

C. Purchase products and systems selected by Architect from the designated supplier.

1.5 ACTION SUBMITTALS

A. Submit proposals for purchase of products or systems included in allowances in the form specified for Change Orders.

1.6 INFORMATIONAL SUBMITTALS

A. Submit invoices or delivery slips to show actual quantities of materials delivered to the site for use in fulfillment of each allowance.

B. Submit time sheets and other documentation to show labor time and cost for installation of allowance items that include installation as part of the allowance.

C. Coordinate and process submittals for allowance items in same manner as for other portions of the Work.

1.7 QUANTITY ALLOWANCES

A. Allowance shall include cost to Contractor of specific products and materials ordered by Owner or selected by Architect under allowance and shall include [taxes,]freight[,] and delivery to Project site.

B. Unless otherwise indicated, Contractor's costs for receiving and handling at Project site, labor, installation, overhead and profit, and similar costs related to products and materials ordered by Owner or selected by Architect under allowance shall be included as part of the Contract Sum and not part of the allowance.

C. Unused Materials: Return unused materials purchased under an allowance to manufacturer or supplier for credit to Owner, after installation has been completed and accepted.

1. If requested by Architect, retain and prepare unused material for storage by Owner. Deliver unused material to Owner's storage space as directed.

1.8 ADJUSTMENT OF ALLOWANCES

A. Allowance Adjustment: To adjust allowance amounts, prepare a Change Order proposal based on the difference between purchase amount and the allowance, multiplied by final measurement of work-in-place where applicable. If applicable, include reasonable allowances for cutting losses, tolerances, mixing wastes, normal product imperfections, and similar margins.

1. Include installation costs in purchase amount only where indicated as part of the allowance.
2. If requested, prepare explanation and documentation to substantiate distribution of overhead costs and other markups.
3. Submit substantiation of a change in scope of Work, if any, claimed in Change Orders related to unit-cost allowances.
4. Owner reserves the right to establish the quantity of work-in-place by independent quantity survey, measure, or count.

B. Submit claims for increased costs because of a change in scope or nature of the allowance described in the Contract Documents, whether for the purchase order amount or Contractor's handling, labor, installation, overhead, and profit.

1. Do not include Contractor's or subcontractor's indirect expense in the Change Order cost amount unless it is clearly shown that the nature or extent of Work has changed from what could have been foreseen from information in the Contract Documents.
2. No change to Contractor's indirect expense is permitted for selection of higher- or lower-priced materials or systems of the same scope and nature as originally indicated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine products covered by an allowance promptly on delivery for damage or defects. Return damaged or defective products to manufacturer for replacement.

3.2 PREPARATION

A. Coordinate materials and their installation for each allowance with related materials and installations to ensure that each allowance item is completely integrated and interfaced with related work.

3.3 SCHEDULE OF ALLOWANCES

A. Allowance No. 1: Unit-Cost Allowance: Includea unit cost allowance for replacement gypsum board at the existing parapet per 10 sq. ft.

B. Allowance No. 2: Unit-Cost Allowance: Includea unit cost allowance for replacement plywood at the existing parapet per 10 sq. ft.

C. Allowance No. 3: Quantity Allowance: Include 350 sq. ft. of duct insulation installed, includingmaterial and labor and related accessories, as specified in Section 230713 "Duct Insulation."

END OF SECTION 012100

SECTION 012300 - ALTERNATES

PART 1 - GENERAL

1.1 SUMMARY

A. This 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 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. The cost or credit for each alternate is the net addition to or deduction from the Contract Sum to incorporate alternate into the Work. No other adjustments are made to the Contract Sum.

1.3 PROCEDURES

A. Coordination: Modify 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. Notification: Immediately following award of the Contract, notify each party involved, in writing, of the status of each alternate. Indicate if alternates have been accepted, rejected, or deferred for later consideration. Include a complete description of negotiated modifications to alternates.

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

D. 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 No. 1: Shall be an ADD or DEDUCT Alternate for the following work;
   1. Provide a PMMA liquid-applied roof assembly with a self-adhered modified bitumen base ply in lieu of the 2-ply modified bitumen roof assembly with elastomeric coating.

END OF SECTION 012300

SECTION 012500 - SUBSTITUTION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for substitutions.

B. Related Requirements:

1. Section 012300 "Alternates" for products selected under an alternate.
2. Section 016000 "Product Requirements" for requirements for submitting comparable product submittals for products by listed manufacturers.

1.3 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.

1.4 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 facsimile of form provided in Project Manual.
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 architects and owners.
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. Architect's Action: If necessary, Architect will request additional information or documentation for evaluation within seven days of receipt of a request for substitution. Architect 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 Architect's Supplemental Instructions for minor changes in the Work.
    b. Use product specified if Architect does not issue a decision on use of a proposed substitution within time allocated.

1.5 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.

1.6 PROCEDURES

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

1.7 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: Architect will consider Contractor's request for substitution when the following conditions are satisfied. If the following conditions are not satisfied, Architect 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. Requested substitution provides sustainable design characteristics that specified product provided for compliance with LEED requirements.
c. Substitution request is fully documented and properly submitted.
d. Requested substitution will not adversely affect Contractor's construction schedule.
e. Requested substitution has received necessary approvals of authorities having jurisdiction.
f. Requested substitution is compatible with other portions of the Work.
g. Requested substitution has been coordinated with other portions of the Work.
h. Requested substitution provides specified warranty.
i. 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 unless otherwise indicated.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 012500

SECTION 012600 - CONTRACT MODIFICATION PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

B. Related Requirements:

1. Section 012500 "Substitution Procedures" for administrative procedures for handling requests for substitutions made after the Contract award.

1.3 MINOR CHANGES IN THE WORK

A. Architect will issue supplemental instructions authorizing minor changes in the Work, not involving adjustment to the Contract Sum or the Contract Time, on AIA Document G710.

1.4 PROPOSAL REQUESTS

A. Owner-Initiated Proposal Requests: Architect 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 Architect are not instructions either to stop work in progress or to execute the proposed change.
2. Within time specified in Proposal Request 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.
    e. Quotation Form: Use forms acceptable to Architect.

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 Architect.

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.
7. Proposal Request Form: Use form acceptable to Architect.

1.5 ADMINISTRATIVE CHANGE ORDERS

A. Allowance Adjustment: See Section 012100 "Allowances" for administrative procedures for preparation of Change Order Proposal for adjusting the Contract Sum to reflect actual costs of allowances.

1.6 CHANGE ORDER PROCEDURES

A. On Owner's approval of a Work Change Proposal Request, Architect will issue a Change Order for signatures of Owner and Contractor on AIA Document G701.

1.7 CONSTRUCTION CHANGE DIRECTIVE

A. Construction Change Directive: Architect may issue a Construction Change Directive on AIA Document G714 . 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.

1.8 WORK CHANGE DIRECTIVE

A. Work Change Directive: Architect may issue a Work Change Directive on EJCDC Document C-940 . Work Change Directive instructs Contractor to proceed with a change in the Work, for subsequent inclusion in a Change Order.

1. Work 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 Work 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 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements necessary to prepare and process Applications for Payment.

B. Related Requirements:

1. Section 012100 "Allowances" for procedural requirements governing the handling and processing of allowances.
2. Section 012600 "Contract Modification Procedures" for administrative procedures for handling changes to the Contract.
3. Section 013200 "Construction Progress Documentation" for administrative requirements governing the preparation and submittal of the Contractor's construction schedule.

1.3 DEFINITIONS

A. Schedule of Values: A statement furnished by Contractor allocating portions of the Contract Sum to various portions of the Work and used as the basis for reviewing Contractor's Applications for Payment.

1.4 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 Architect at earliest possible date, but no later than seven days before the date scheduled for submittal of initial Applications for Payment.
3. Subschedules for Phased Work: Where the Work is separated into phases requiring separately phased payments, provide subschedules showing values coordinated with each phase of payment.
4. Subschedules for Separate Elements of Work: Where the Contractor's construction schedule defines separate elements of the Work, provide subschedules showing values coordinated with each element.

5. Subschedules for Separate Design Contracts: Where the Owner has retained design professionals under separate contracts who will each provide certification of payment requests, provide subschedules showing values coordinated with the scope of each design services contract, as described in Section 011000 "Summary."

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. Identification: Include the following Project identification on the schedule of values:

    a. Project name and location.
    b. Name of Architect.
    c. Architect's Project number.
    d. Contractor's name and address.
    e. Date of submittal.

2. Arrange schedule of values consistent with format of AIA Document G703.
3. Arrange the schedule of values in tabular form, with separate columns to indicate the following for each item listed:

    a. Related Specification Section or Division.
    b. Description of the Work.
    c. Name of subcontractor.
    d. Name of manufacturer or fabricator.
    e. Name of supplier.
    f. Change Orders (numbers) that affect value.
    g. Dollar value of the following, as a percentage of the Contract Sum to nearest one-hundredth percent, adjusted to total 100 percent. Round dollar amounts to whole dollars, with total equal to Contract Sum.

        1) Labor.
        2) Materials.
        3) Equipment.

4. 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.
5. 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.

6. 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.
7. Purchase Contracts: Provide a separate line item in the schedule of values for each purchase contract. Show line-item value of purchase contract. Indicate Owner payments or deposits, if any, and balance to be paid by Contractor.

8. Overhead Costs: Include total cost and proportionate share of general overhead and profit for each line item.
9. 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.
10. Closeout Costs. Include separate line items under Contractor and principal subcontracts for Project closeout requirements in an amount totaling fivepercent of the Contract Sum and subcontract amount.
11. 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.

1.5 APPLICATIONS FOR PAYMENT

A. Each Application for Payment following the initial Application for Payment shall be consistent with previous applications and payments as certified by Architect and paid for by Owner.

B. Payment Application Times: The date for each progress payment is indicated in the Agreement between Owner and Contractor. The period of construction work covered by each Application for Payment is the period indicated in the Agreement.

C. Payment Application Times: Following the reivew and approval of the Draft Application, submit Application for Payment to Architect by the 25th of the month. The period covered by each Application for Payment is one month, ending on [last day of the month] <25th>.

1. Unless otherwise requested, or about the 18th of each month, submit a draft applcation for payement and review of this application by the Campus Projects Project Manager at the progress meeting or other meeting established for this review. obtain the Project Manager's agreement concerning percentages of completion and the amounts applied for.

D. Application for Payment Forms: Use AIA Document G702 and AIA Document G703 as form for Applications for Payment.

E. Application Preparation: Complete every entry on form. Notarize and execute by a person authorized to sign legal documents on behalf of Contractor. Architect will return incomplete applications without action.

1. Entries shall match data on the schedule of values and Contractor's construction schedule. Use updated schedules if revisions were made.
2. Include amounts for work completed following previous Application for Payment, whether or not payment has been received. Include only amounts for work completed at time of Application for Payment.
3. Include amounts of Change Orders and Construction Change Directives issued before last day of construction period covered by application.
4. Indicate separate amounts for work being carried out under Owner-requested project acceleration.

F. Stored Materials: Include in Application for Payment amounts applied for materials or equipment purchased or fabricated and stored, but not yet installed. Differentiate between items stored on-site and items stored off-site.

1. Provide certificate of insurance, evidence of transfer of title to Owner, and consent of surety to payment for stored materials.
2. Provide supporting documentation that verifies amount requested, such as paid invoices. Match amount requested with amounts indicated on documentation; do not include overhead and profit on stored materials.
3. Provide summary documentation for stored materials indicating the following:

    a. Value of materials previously stored and remaining stored as of date of previous Applications for Payment.
    b. Value of previously stored materials put in place after date of previous Application for Payment and on or before date of current Application for Payment.
    c. Value of materials stored since date of previous Application for Payment and remaining stored as of date of current Application for Payment.

G. Transmittal: Submit five signed and notarized original copies of each Application for Payment to Architect by a method ensuring receipt within 24 hours. One copy shall include waivers of lien and similar attachments if required.

1. Transmit each copy with a transmittal form listing attachments and recording appropriate information about application.

H. Waivers of Mechanic's Lien: With each Application for Payment, submit waivers of mechanic's lien from entities lawfully entitled to file a mechanic's lien arising out of the Contract and related to the Work covered by the payment.

1. Submit partial waivers on each item for amount requested in previous application, after deduction for retainage, on each item.
2. When an application shows completion of an item, submit conditional final or full waivers.
3. Owner reserves the right to designate which entities involved in the Work must submit waivers.
4. Submit final Application for Payment with or preceded by conditional final waivers from every entity involved with performance of the Work covered by the application who is lawfully entitled to a lien.
5. Waiver Forms: Submit executed waivers of lien on forms acceptable to Owner.

I. Initial Application for Payment: Administrative actions and submittals that must precede or coincide with submittal of first Application for Payment include the following:

1. List of subcontractors.
2. Schedule of values.
3. Contractor's construction schedule (preliminary if not final).
4. Combined Contractor's construction schedule (preliminary if not final) incorporating Work of multiple contracts, with indication of acceptance of schedule by each Contractor.
5. Products list (preliminary if not final).
6. Sustainable design action plans, including preliminary project materials cost data.
7. Schedule of unit prices.
8. Submittal schedule (preliminary if not final).
9. List of Contractor's staff assignments.
10. List of Contractor's principal consultants.
11. Copies of building permits.
12. Copies of authorizations and licenses from authorities having jurisdiction for performance of the Work.
13. Initial progress report.

14. Report of preconstruction conference.
15. Certificates of insurance and insurance policies.
16. Performance and payment bonds.
17. Data needed to acquire Owner's insurance.

J. Application for Payment at Substantial Completion: After Architect issues the Certificate of Substantial Completion, submit an Application for Payment showing 100 percent completion for portion of the Work claimed as substantially complete.

1. Include documentation supporting claim that the Work is substantially complete and a statement showing an accounting of changes to the Contract Sum.
2. This application shall reflect Certificate(s) of Substantial Completion issued previously for Owner occupancy of designated portions of the Work.

K. Final Payment Application: After completing Project closeout requirements, submit final Application for Payment with releases and supporting documentation not previously submitted and accepted, including, but not limited, to the following:

1. Evidence of completion of Project closeout requirements.
2. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.
3. Updated final statement, accounting for final changes to the Contract Sum.
4. AIA Document G706.
5. AIA Document G706A.
6. AIA Document G707.
7. Evidence that claims have been settled.
8. Final meter readings for utilities, a measured record of stored fuel, and similar data as of date of Substantial Completion or when Owner took possession of and assumed responsibility for corresponding elements of the Work.
9. Final liquidated damages settlement statement.

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 RELATED DOCUMENTS

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

1.2 SUMMARY

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

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

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

C. Related Requirements:

1. Section 013200 "Construction Progress Documentation" for preparing and submitting Contractor's construction schedule.
2. Section 017300 "Execution" for procedures for coordinating general installation and field-engineering services, including establishment of benchmarks and control points.
3. Section 017700 "Closeout Procedures" for coordinating closeout of the Contract.
4. Section 019113 "General Commissioning Requirements" for coordinating the Work with Owner's Commissioning Authority.

1.3 DEFINITIONS

A. BIM: Building Information Modeling.

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

1.4 INFORMATIONAL SUBMITTALS

A. Subcontract List: Prepare a written summary identifying individuals or firms proposed for each portion of the Work, including those who are to furnish products or equipment fabricated to a special design. Include the following information in tabular form:

1. Name, address, telephone number, and email address of entity performing subcontract or supplying products.
2. Number and title of related Specification Section(s) covered by subcontract.
3. Drawing number and detail references, as appropriate, covered by subcontract.

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

1. Post copies of list in project meeting room, in temporary field office, in web-based Project software directory, and in prominent location in built facility. Keep list current at all times.

1.5 GENERAL COORDINATION PROCEDURES

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

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

B. Coordination: Each contractor shall cooperate with Project coordinator who shall coordinate its construction operations with those of other contractors and entities to ensure efficient and orderly installation of each part of the Work. Each contractor shall coordinate its own operations with operations included in different Sections that depend on each other for proper installation, connection, and operation.

1. Schedule construction operations in sequence required to obtain the best results where installation of one part of the Work depends on installation of other components, before or after its own installation.
2. Coordinate installation of different components with other contractors to ensure maximum performance and accessibility for required maintenance, service, and repair.
3. Make adequate provisions to accommodate items scheduled for later installation.

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

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

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

1. Preparation of Contractor's construction schedule.
2. Preparation of the schedule of values.
3. Installation and removal of temporary facilities and controls.
4. Delivery and processing of submittals.
5. Progress meetings.
6. Preinstallation conferences.
7. Project closeout activities.
8. Startup and adjustment of systems.

1.6 COORDINATION DRAWINGS

A. Coordination Drawings, General: Prepare coordination drawings according to requirements in individual Sections, and additionally where installation is not completely indicated on Shop Drawings, where limited space availability necessitates coordination, or if coordination is required to facilitate integration of products and materials fabricated or installed by more than one entity.

1. Content: Project-specific information, drawn accurately to a scale large enough to indicate and resolve conflicts. Do not base coordination drawings on standard printed data. Include the following information, as applicable:

   a. Use applicable Drawings as a basis for preparation of coordination drawings. Prepare sections, elevations, and details as needed to describe relationship of various systems and components.
   b. Coordinate the addition of trade-specific information to coordination drawings by multiple contractors in a sequence that best provides for coordination of the information and resolution of conflicts between installed components before submitting for review.
   c. Indicate functional and spatial relationships of components of architectural, structural, civil, mechanical, and electrical systems.
   d. Indicate space requirements for routine maintenance and for anticipated replacement of components during the life of the installation.
   e. Show location and size of access doors required for access to concealed dampers, valves, and other controls.
   f. Indicate required installation sequences.
   g. Indicate dimensions shown on Drawings. Specifically note dimensions that appear to be in conflict with submitted equipment and minimum clearance requirements. Provide alternative sketches to Architect indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.

B. Coordination Drawing Organization: Organize coordination drawings as follows:

1. Mechanical and Plumbing Work: Show the following:

   a. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
   b. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.

c. Fire-rated enclosures around ductwork.

2. Electrical Work: Show the following:

   a. Runs of vertical and horizontal conduit 1-1/4 inches in diameter and larger.
   b. Panel board, switch board, switchgear, transformer, busway, generator, and motor-control center locations.
   c. Location of pull boxes and junction boxes, dimensioned from column center lines.

3. Roofing System: Show the following:

   a. Locations of all mechanical equipment.
   b. Roof slopes..

4. Review: Architect will review coordination drawings to confirm that in general the Work is being coordinated, but not for the details of the coordination, which are Contractor's responsibility. If Architect determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Architect will so inform Contractor, who shall make suitable modifications and resubmit.
5. Coordination Drawing Prints: Prepare coordination drawing prints according to requirements in Section 013300 "Submittal Procedures."

1.7 REQUEST FOR INFORMATION (RFI)

A. General: Immediately on discovery of the need for additional information, clarification, or interpretation of the Contract Documents, Contractor shall prepare and submit an RFI in the form specified.

   1. Architect will return without response those RFIs submitted to Architect by other entities controlled by Contractor.
   2. Coordinate and submit RFIs in a prompt manner so as to avoid delays in Contractor's work or work of subcontractors.

B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:

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

a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.

C. RFI Forms: AIA Document G716.

1. Attachments shall be electronic files in PDF format.

D. Architect's Action: Architect will review each RFI, determine action required, and respond. Allow seven working days for Architect's response for each RFI. RFIs received by Architect after 1:00 p.m. will be considered as received the following working day.

1. The following Contractor-generated RFIs will be returned without action:

a. Requests for approval of submittals.
b. Requests for approval of substitutions.
c. Requests for approval of Contractor's means and methods.
d. Requests for coordination information already indicated in the Contract Documents.
e. Requests for adjustments in the Contract Time or the Contract Sum.
f. Requests for interpretation of Architect's actions on submittals.
g. Incomplete RFIs or inaccurately prepared RFIs.

2. Architect's action may include a request for additional information, in which case Architect's time for response will date from time of receipt by Architect of additional information.
3. Architect's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."

a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Architect in writing within 10 days of receipt of the RFI response.

E. RFI Log: Prepare, maintain, and submit a tabular log of RFIs organized by the RFI number. Submit log weekly. Use software log that is part of web-based Project software.

1. Project name.
2. Name and address of Contractor.
3. Name and address of Architect.
4. RFI number including RFIs that were returned without action or withdrawn.
5. RFI description.
6. Date the RFI was submitted.
7. Date Architect's response was received.
8. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
9. Identification of related Field Order, Work Change Directive, and Proposal Request, as appropriate.

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

1.8 DIGITAL PROJECT MANAGEMENT PROCEDURES

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

B. Web-Based Project Software: Use Architect's web-based Project software site for purposes of hosting and managing Project communication and documentation until Final Completion.

1. Web-based Project software site includes, at a minimum, the following features:

a. Compilation of Project data, including Contractor, subcontractors, Architect, architect's consultants, Owner, and other entities involved in Project. Include names of individuals and contact information.
b. Creation, logging, tracking, and notification for Project communications required in other Specification Sections, including, but not limited to, RFIs, submittals, Minor Changes in the Work, Construction Change Directives, and Change Orders.
c. Processing and tracking of contract modifications.
d. Document management for Drawings, Specifications, and coordination drawings, including revision control.
e. Mobile device compatibility, including smartphones and tablets.

C. PDF Document Preparation: Where PDFs are required to be submitted to Architect, prepare as follows:

1. Assemble complete submittal package into a single indexed file incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
2. Name file with submittal number or other unique identifier, including revision identifier.
3. Certifications: Where digitally submitted certificates and certifications are required, provide a digital signature with digital certificate on where indicated.

1.9 PROJECT MEETINGS

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

1. Attendees: Inform participants and others involved, and individuals whose presence is required, of date and time of each meeting. Notify Owner and Architect of scheduled meeting dates and times a minimum of 10 working days prior to meeting.
2. Agenda: Prepare the meeting agenda. Distribute the agenda to all invited attendees.
3. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Architect, within days of the meeting.

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

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

    a. Responsibilities and personnel assignments.
    b. Tentative construction schedule.
    c. Phasing.
    d. Critical work sequencing and long lead items.
    e. Designation of key personnel and their duties.
    f. Lines of communications.
    g. Use of web-based Project software.
    h. Procedures for processing field decisions and Change Orders.
    i. Procedures for RFIs.
    j. Procedures for testing and inspecting.
    k. Procedures for processing Applications for Payment.
    l. Distribution of the Contract Documents.
    m. Submittal procedures.
    n. Sustainable design requirements.
    o. Preparation of Record Documents.
    p. Use of the premises and existing building.
    q. Work restrictions.
    r. Working hours.
    s. Owner's occupancy requirements.
    t. Responsibility for temporary facilities and controls.
    u. Procedures for moisture and mold control.
    v. Procedures for disruptions and shutdowns.
    w. Construction waste management and recycling.
    x. Parking availability.
    y. Office, work, and storage areas.
    z. Equipment deliveries and priorities.
    aa. First aid.
    bb. Security.
    cc. Progress cleaning.

3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.

C. Preinstallation Conferences: Conduct a preinstallation conference at Project site before each construction activity when required by other sections and when required for coordination with other construction.

1. Attendees: Installer and representatives of manufacturers and fabricators involved in or affected by the installation and its coordination or integration with other materials and installations that have preceded or will follow, shall attend the meeting. Advise Architect, and Owner's Commissioning Authority of scheduled meeting dates.
2. Agenda: Review progress of other construction activities and preparations for the particular activity under consideration, including requirements for the following:

    a. Contract Documents.
    b. Options.
    c. Related RFIs.

d. Related Change Orders.
e. Purchases.
f. Deliveries.
g. Submittals.
h. Sustainable design requirements.
i. Review of mockups.
j. Possible conflicts.
k. Compatibility requirements.
l. Time schedules.
m. Weather limitations.
n. Manufacturer's written instructions.
o. Warranty requirements.
p. Compatibility of materials.
q. Acceptability of substrates.
r. Temporary facilities and controls.
s. Space and access limitations.
t. Regulations of authorities having jurisdiction.
u. Testing and inspecting requirements.
v. Installation procedures.
w. Coordination with other work.
x. Required performance results.
y. Protection of adjacent work.
z. Protection of construction and personnel.

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

D. Project Closeout Conference: Schedule and conduct a project closeout conference, at a time convenient to Owner and Architect, but no later than 90 days prior to the scheduled date of Substantial Completion.

1. Conduct the conference to review requirements and responsibilities related to Project closeout.
2. Attendees: Authorized representatives of Owner, Owner's Commissioning Authority, Architect, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the meeting. Participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
3. Agenda: Discuss items of significance that could affect or delay Project closeout, including the following:

a. Preparation of Record Documents.
b. Procedures required prior to inspection for Substantial Completion and for final inspection for acceptance.
c. Procedures for completing and archiving web-based Project software site data files.
d. Submittal of written warranties.
e. Requirements for completing sustainable design documentation.
f. Requirements for preparing operations and maintenance data.
g. Requirements for delivery of material samples, attic stock, and spare parts.
h. Requirements for demonstration and training.

i. Preparation of Contractor's punch list.
j. Procedures for processing Applications for Payment at Substantial Completion and for final payment.
k. Submittal procedures.
l. Coordination of separate contracts.
m. Owner's partial occupancy requirements.
n. Installation of Owner's furniture, fixtures, and equipment.
o. Responsibility for removing temporary facilities and controls.

4. Minutes: Entity conducting meeting will record and distribute meeting minutes.

E. Progress Meetings: Conduct progress meetings at biweekly intervals.

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

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

1) Review schedule for next period.

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

1) Interface requirements.
2) Sequence of operations.
3) Resolution of BIM component conflicts.
4) Status of submittals.
5) Status of sustainable design documentation.
6) Deliveries.
7) Off-site fabrication.
8) Access.
9) Site use.
10) Temporary facilities and controls.
11) Progress cleaning.
12) Quality and work standards.
13) Status of correction of deficient items.
14) Field observations.
15) Status of RFIs.
16) Status of Proposal Requests.
17) Pending changes.
18) Status of Change Orders.
19) Pending claims and disputes.

20) Documentation of information for payment requests.

4. Minutes: Entity responsible for conducting the meeting will record and distribute the meeting minutes to each party present and to parties requiring information.

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

F. Coordination Meetings: Conduct Project coordination meetings at biweekly intervals. Project coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and preinstallation conferences.

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

a. Combined Contractor's Construction Schedule: Review progress since the last coordination meeting. Determine whether each contract is on time, ahead of schedule, or behind schedule, in relation to combined Contractor's construction schedule. Determine how construction behind schedule will be expedited; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities will be completed within the Contract Time.
b. Schedule Updating: Revise combined Contractor's construction schedule after each coordination meeting where revisions to the schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.
c. Review present and future needs of each contractor present, including the following:

1) Interface requirements.
2) Sequence of operations.
3) Resolution of BIM component conflicts.
4) Status of submittals.
5) Deliveries.
6) Off-site fabrication.
7) Access.
8) Site use.
9) Temporary facilities and controls.
10) Work hours.
11) Hazards and risks.
12) Progress cleaning.
13) Quality and work standards.
14) Status of RFIs.
15) Proposal Requests.
16) Change Orders.
17) Pending changes.

3. Reporting: Record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013100

SECTION 013200 - CONSTRUCTION PROGRESS DOCUMENTATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for documenting the progress of construction during performance of the Work, including the following:

1. Startup construction schedule.
2. Contractor's Construction Schedule.
3. Construction schedule updating reports.
4. Daily construction reports.
5. Material location reports.
6. Site condition reports.
7. Unusual event reports.

1.3 INFORMATIONAL SUBMITTALS

A. Format for Submittals: Submit required submittals in the following format:

1. Working electronic copy of schedule file, where indicated.
2. PDF file.
3. Two paper copies, of sufficient size to display entire period or schedule, as required.

B. Startup construction schedule.

1. Submittal of cost-loaded, startup construction schedule will not constitute approval of schedule of values for cost-loaded activities.

C. Contractor's Construction Schedule: Initial schedule, of size required to display entire schedule for entire construction period.

1. Submit a working digital copy of schedule, using software indicated, and labeled to comply with requirements for submittals.

D. Construction Schedule Updating Reports: Submit with Applications for Payment.

E. Daily Construction Reports: Submit at weekly intervals.

F. Material Location Reports: Submit at weekly intervals.

G. Site Condition Reports: Submit at time of discovery of differing conditions.

H. Unusual Event Reports: Submit at time of unusual event.

I. Qualification Data: For scheduling consultant.

1.4 COORDINATION

A. Coordinate Contractor's Construction Schedule with the schedule of values, list of subcontracts, submittal schedule, progress reports, payment requests, and other required schedules and reports.

1. Secure time commitments for performing critical elements of the Work from entities involved.
2. Coordinate each construction activity in the network with other activities and schedule them in proper sequence.

1.5 CONTRACTOR'S CONSTRUCTION SCHEDULE, GENERAL

A. Computer Scheduling Software: Prepare schedules using current version of a program that has been developed specifically to manage construction schedules.

B. Scheduling Consultant: Engage a consultant to provide planning, evaluation, and reporting using CPM scheduling.

C. Time Frame: Extend schedule from date established for the Notice to Proceed to date of final completion.

1. Contract completion date shall not be changed by submission of a schedule that shows an early completion date, unless specifically authorized by Change Order.

D. Activities: Treat each floor or separate area as a separate numbered activity for each main element of the Work. Comply with the following:

1. Activity Duration: Define activities so no activity is longer than 20 days, unless specifically allowed by Architect.
2. Procurement Activities: Include procurement process activities for the following long lead items and major items, requiring a cycle of more than 60 days, as separate activities in schedule. Procurement cycle activities include, but are not limited to, submittals, approvals, purchasing, fabrication, and delivery.

    a. HVAC units.

3. Submittal Review Time: Include review and resubmittal times indicated in Section 013300 "Submittal Procedures" in schedule. Coordinate submittal review times in Contractor's Construction Schedule with submittal schedule.
4. Startup and Testing Time: Include no fewer than 15 days for startup and testing.
5. Commissioning Time: Include no fewer than 15 days for commissioning.
6. Substantial Completion: Indicate completion in advance of date established for Substantial Completion, and allow time for Architect's administrative procedures necessary for certification of Substantial Completion.
7. Punch List and Final Completion: Include not more than 30 days for completion of punch list items and final completion.

E. Constraints: Include constraints and work restrictions indicated in the Contract Documents and as follows in schedule, and show how the sequence of the Work is affected.

1. Phasing: Arrange list of activities on schedule by phase.
2. Work under More Than One Contract: Include a separate activity for each contract.
3. Work by Owner: Include a separate activity for each portion of the Work performed by Owner.
4. Products Ordered in Advance: Include a separate activity for each product. Include delivery date indicated in Section 011000 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
5. Owner-Furnished Products: Include a separate activity for each product. Include delivery date indicated in Section 011000 "Summary." Delivery dates indicated stipulate the earliest possible delivery date.
6. Work Restrictions: Show the effect of the following items on the schedule:

    a. Coordination with existing construction.
    b. Limitations of continued occupancies.
    c. Uninterruptible services.
    d. Partial occupancy before Substantial Completion.
    e. Use-of-premises restrictions.
    f. Provisions for future construction.
    g. Seasonal variations.
    h. Environmental control.

7. Work Stages: Indicate important stages of construction for each major portion of the Work, including, but not limited to, the following:

    a. Subcontract awards.
    b. Submittals.
    c. Purchases.
    d. Mockups.
    e. Fabrication.
    f. Sample testing.
    g. Deliveries.
    h. Installation.
    i. Tests and inspections.
    j. Adjusting.
    k. Curing.
    l. Building flush-out.
    m. Startup and placement into final use and operation.
    n. Commissioning.

8. Construction Areas: Identify each major area of construction for each major portion of the Work. Indicate where each construction activity within a major area must be sequenced or integrated with other construction activities to provide for the following:

    a. Structural completion.
    b. Temporary enclosure and space conditioning.
    c. Permanent space enclosure.
    d. Completion of mechanical installation.
    e. Completion of electrical installation.
    f. Substantial Completion.

F. Milestones: Include milestones indicated in the Contract Documents in schedule, including, but not limited to, the Notice to Proceed, Substantial Completion, and final completion, and the following interim milestones:

1. Delivery of HVAC equipment.
2. Completion of roof installation.

G. Cost Correlation: Superimpose a cost correlation timeline, indicating planned and actual costs. On the line, show planned and actual dollar volume of the Work performed as of planned and actual dates used for preparation of payment requests.

1. See Section 012900 "Payment Procedures" for cost reporting and payment procedures.

H. Upcoming Work Summary: Prepare summary report indicating activities scheduled to occur or commence prior to submittal of next schedule update. Summarize the following issues:

1. Unresolved issues.
2. Unanswered Requests for Information.
3. Rejected or unreturned submittals.
4. Notations on returned submittals.
5. Pending modifications affecting the Work and the Contract Time.

I. Contractor's Construction Schedule Updating: At monthly intervals, update schedule to reflect actual construction progress and activities. Issue schedule one week before each regularly scheduled progress meeting.

1. Revise schedule immediately after each meeting or other activity where revisions have been recognized or made. Issue updated schedule concurrently with the report of each such meeting.
2. Include a report with updated schedule that indicates every change, including, but not limited to, changes in logic, durations, actual starts and finishes, and activity durations.
3. As the Work progresses, indicate final completion percentage for each activity.

J. Recovery Schedule: When periodic update indicates the Work is 14 or more calendar days behind the current approved schedule, submit a separate recovery schedule indicating means by which Contractor intends to regain compliance with the schedule. Indicate changes to working hours, working days, crew sizes, equipment required to achieve compliance, and date by which recovery will be accomplished.

K. Distribution: Distribute copies of approved schedule to Architect Owner, separate contractors, testing and inspecting agencies, and other parties identified by Contractor with a need-to-know schedule responsibility.

1. Post copies in Project meeting rooms and temporary field offices.
2. When revisions are made, distribute updated schedules to the same parties and post in the same locations. Delete parties from distribution when they have completed their assigned portion of the Work and are no longer involved in performance of construction activities.

1.6 STARTUP CONSTRUCTION SCHEDULE

A. Gantt-Chart Schedule: Submit startup, horizontal, Gantt-chart-type construction schedule within seven days of date established for the Notice to Proceed.

B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line. Outline significant construction activities for first 90 days of construction. Include skeleton diagram for the remainder of the Work and a cash requirement prediction based on indicated activities.

1.7 GANTT-CHART SCHEDULE REQUIREMENTS

A. Gantt-Chart Schedule: Submit a comprehensive, fully developed, horizontal, Gantt-chart-type, Contractor's Construction Schedule within 30 days of date established for the Notice to Proceed.

1. Base schedule on the startup construction schedule and additional information received since the start of Project.

B. Preparation: Indicate each significant construction activity separately. Identify first workday of each week with a continuous vertical line.

1. For construction activities that require three months or longer to complete, indicate an estimated completion percentage in 10 percent increments within time bar.

1.8 REPORTS

A. Daily Construction Reports: Prepare a daily construction report recording the following information concerning events at Project site:

1. List of subcontractors at Project site.
2. List of separate contractors at Project site.
3. Approximate count of personnel at Project site.
4. Equipment at Project site.
5. Material deliveries.
6. High and low temperatures and general weather conditions, including presence of rain or snow.
7. Testing and inspection.
8. Accidents.
9. Meetings and significant decisions.
10. Unusual events.
11. Stoppages, delays, shortages, and losses.
12. Meter readings and similar recordings.
13. Emergency procedures.
14. Orders and requests of authorities having jurisdiction.
15. Change Orders received and implemented.
16. Construction Change Directives received and implemented.
17. Services connected and disconnected.
18. Equipment or system tests and startups.
19. Partial completions and occupancies.
20. Substantial Completions authorized.

B. Material Location Reports: At monthly intervals, prepare and submit a comprehensive list of materials delivered to and stored at Project site. List shall be cumulative, showing materials previously reported plus items recently delivered. Include with list a statement of progress on and delivery dates for materials or items of equipment fabricated or stored away from Project site. Indicate the following categories for stored materials:

1. Material stored prior to previous report and remaining in storage.
2. Material stored prior to previous report and since removed from storage and installed.
3. Material stored following previous report and remaining in storage.

C. Site Condition Reports: Immediately on discovery of a difference between site conditions and the Contract Documents, prepare and submit a detailed report. Submit with a Request for Information. Include a detailed description of the differing conditions, together with recommendations for changing the Contract Documents.

D. Unusual Event Reports: When an event of an unusual and significant nature occurs at Project site, whether or not related directly to the Work, prepare and submit a special report. List chain of events, persons participating, responses by Contractor's personnel, evaluation of results or effects, and similar pertinent information. Advise Owner in advance when these events are known or predictable.

1. Submit unusual event reports directly to Owner within [one] <Insert number> day(s) of an occurrence. Distribute copies of report to parties affected by the occurrence.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013200

SECTION 013233 - PHOTOGRAPHIC DOCUMENTATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Preconstruction photographs.
2. Periodic construction photographs.
3. Final completion construction photographs.

B. Related Requirements:

1. Section 017700 "Closeout Procedures" for submitting photographic documentation as Project Record Documents at Project closeout.
2. Section 017900 "Demonstration and Training" for submitting video recordings of demonstration of equipment and training of Owner's personnel.
3. Section 024119 "Selective Demolition" for photographic documentation before selective demolition operations commence.

1.3 INFORMATIONAL SUBMITTALS

A. Key Plan: Submit key plan of Project site and building with notation of vantage points marked for location and direction of each photograph. Indicate elevation or story of construction. Include same information as corresponding photographic documentation.

B. Digital Photographs: Submit image files within three days of taking photographs.

1. Submit photos by uploading to web-based project software site. Include copy of key plan indicating each photograph's location and direction.
2. Identification: Provide the following information with each image description in web-based project software site:

a. Name of Project.
b. Name and contact information for photographer.
c. Name of Architect.
d. Name of Contractor.
e. Date photograph was taken.
f. Description of location, vantage point, and direction.
g. Unique sequential identifier keyed to accompanying key plan.

1.4 FORMATS AND MEDIA

A. Digital Photographs: Provide color images in JPG format, produced by a digital camera with minimum sensor size of 12 megapixels, and at an image resolution of not less than 3200 by 2400 pixels, and with vibration-reduction technology. Use flash in low light levels or backlit conditions.

B. Digital Images: Submit digital media as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.

C. Metadata: Record accurate date and time from camera.

D. File Names: Name media files with date and sequential numbering suffix.

1.5 CONSTRUCTION PHOTOGRAPHS

A. Photographer: Engage a qualified photographer to take construction photographs.

B. General: Take photographs with maximum depth of field and in focus.

1. Maintain key plan with each set of construction photographs that identifies each photographic location.

C. Preconstruction Photographs: Before commencement of demolition, take photographs of Project site and surrounding properties, including existing items to remain during construction, from different vantage points, as directed by Architect.

1. Flag construction limits before taking construction photographs.
2. Take 20 photographs to show existing conditions adjacent to property before starting the Work.
3. Take 20 photographs of existing buildings either on or adjoining property to accurately record physical conditions at start of construction.
4. Take additional photographs as required to record settlement or cracking of adjacent structures, pavements, and improvements.

D. Periodic Construction Photographs: Take 20 photographs weekly. Select vantage points to show status of construction and progress since last photographs were taken.

E. Final Completion Construction Photographs: Take 40 photographs after date of Substantial Completion for submission as Project Record Documents. Architect will inform photographer of desired vantage points.

F. Additional Photographs: Architect may request photographs in addition to periodic photographs specified. Additional photographs will be paid for by Change Order and are not included in the Contract Sum.

1. Three days' notice will be given, where feasible.
2. In emergency situations, take additional photographs within 24 hours of request.
3. Circumstances that could require additional photographs include, but are not limited to, the following:

a. Special events planned at Project site.
b. Immediate follow-up when on-site events result in construction damage or losses.

c. Photographs to be taken at fabrication locations away from Project site. These photographs are not subject to unit prices or unit-cost allowances.
d. Substantial Completion of a major phase or component of the Work.
e. Extra record photographs at time of final acceptance.
f. Owner's request for special publicity photographs.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 013233

SECTION 013516 - ALTERATION PROJECT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes special procedures for alteration work.

1.3 DEFINITIONS

A. Alteration Work: This term includes remodeling, renovation, repair, and maintenance work performed within existing spaces or on existing surfaces as part of the Project.

B. Consolidate: To strengthen loose or deteriorated materials in place.

C. Design Reference Sample: A sample that represents the Architect's prebid selection of work to be matched; it may be existing work or work specially produced for the Project.

D. Dismantle: To remove by disassembling or detaching an item from a surface, using gentle methods and equipment to prevent damage to the item and surfaces; disposing of items unless indicated to be salvaged or reinstalled.

E. Match: To blend with adjacent construction and manifest no apparent difference in material type, species, cut, form, detail, color, grain, texture, or finish; as approved by Architect.

F. Refinish: To remove existing finishes to base material and apply new finish to match original, or as otherwise indicated.

G. Repair: To correct damage and defects, retaining existing materials, features, and finishes. This includes patching, piecing-in, splicing, consolidating, or otherwise reinforcing or upgrading materials.

H. Replace: To remove, duplicate, and reinstall entire item with new material. The original item is the pattern for creating duplicates unless otherwise indicated.

I. Replicate: To reproduce in exact detail, materials, and finish unless otherwise indicated.

J. Reproduce: To fabricate a new item, accurate in detail to the original, and from either the same or a similar material as the original, unless otherwise indicated.

K. Retain: To keep existing items that are not to be removed or dismantled.

L. Strip: To remove existing finish down to base material unless otherwise indicated.

1.4 COORDINATION

A. Alteration Work Subschedule: A construction schedule coordinating the sequencing and scheduling of alteration work for entire Project, including each activity to be performed, and based on Contractor's Construction Schedule. Secure time commitments for performing critical construction activities from separate entities responsible for alteration work.

1. Schedule construction operations in sequence required to obtain best Work results.
2. Coordinate sequence of alteration work activities to accommodate the following:

    a. Tests and inspections.

3. Detail sequence of alteration work, with start and end dates.
4. Utility Services: Indicate how long utility services will be interrupted. Coordinate shutoff, capping, and continuation of utility services.
5. Use of elevator and stairs.
6. Equipment Data: List gross loaded weight, axle-load distribution, and wheel-base dimension data for mobile and heavy equipment proposed for use in existing structure. Do not use such equipment without certification from Contractor's professional engineer that the structure can support the imposed loadings without damage.

B. Pedestrian and Vehicular Circulation: Coordinate alteration work with circulation patterns within Project building(s) and site. Some work is near circulation patterns . Circulation patterns cannot be closed off entirely and in places can be only temporarily redirected around small areas of work. Access to restricted areas may not be obstructed. Plan and execute the Work accordingly.

1.5 PROJECT MEETINGS FOR ALTERATION WORK

A. Preliminary Conference for Alteration Work: Before starting alteration work, conduct conference at Project site.

1. Attendees: In addition to representatives of Owner, Architect, and Contractor, Owner, testing service representative, specialists, and chemical-cleaner manufacturer(s) shall be represented at the meeting.
2. Agenda: Discuss items of significance that could affect progress of alteration work, including review of the following:

    a. Alteration Work Subschedule: Discuss and finalize; verify availability of materials, specialists' personnel, equipment, and facilities needed to make progress and avoid delays.
    b. Fire-prevention plan.
    c. Governing regulations.
    d. Areas where existing construction is to remain and the required protection.
    e. Hauling routes.
    f. Sequence of alteration work operations.
    g. Storage, protection, and accounting for salvaged and specially fabricated items.
    h. Existing conditions, staging, and structural loading limitations of areas where materials are stored.

i. Qualifications of personnel assigned to alteration work and assigned duties.
j. Requirements for extent and quality of work, tolerances, and required clearances.
k. Embedded work such as flashings and lintels, special details, collection of waste, protection of occupants and the public, and condition of other construction that affects the Work or will affect the work.

3. Reporting: Record conference results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from conference.

B. Coordination Meetings: Conduct coordination meetings specifically for alteration work at bi-weekly intervals. Coordination meetings are in addition to specific meetings held for other purposes, such as progress meetings and preinstallation conferences.

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

a. Alteration Work Subschedule: Review progress since last coordination meeting. Determine whether each schedule item is on time, ahead of schedule, or behind schedule. Determine how construction behind schedule will be expedited with retention of quality; secure commitments from parties involved to do so. Discuss whether schedule revisions are required to ensure that current and subsequent activities are completed within the Contract Time.
b. Schedule Updating: Revise Contractor's Alteration Work Subschedule after each coordination meeting where revisions to schedule have been made or recognized. Issue revised schedule concurrently with report of each meeting.
c. Review present and future needs of each entity present, including review items listed in the "Preliminary Conference for Alteration Work" Paragraph in this article and the following:

1) Interface requirements of alteration work with other Project Work.
2) Status of submittals for alteration work.
3) Access to alteration work locations.
4) Effectiveness of fire-prevention plan.
5) Quality and work standards of alteration work.
6) Change Orders for alteration work.

3. Reporting: Record meeting results and distribute copies to everyone in attendance and to others affected by decisions or actions resulting from each meeting.

1.6 INFORMATIONAL SUBMITTALS

A. Alteration Work Subschedule:

1. Submit alteration work subschedule within seven days of date established forNotice to Proceed.

B. Preconstruction Documentation: Show preexisting conditions of adjoining construction and site improvements that are to remain, including finish surfaces, that might be misconstrued as damage caused by Contractor's alteration work operations.

C. Alteration Work Program: Submit 30 days before work begins.

D. Fire-Prevention Plan: Submit 30 days before work begins.

1.7 QUALITY ASSURANCE

A. Specialist Qualifications: An experienced firm regularly engaged in specialty work similar in nature, materials, design, and extent to alteration work as specified in each Section and that has completed a minimum of five recent projects with a record of successful in-service performance that demonstrates the firm's qualifications to perform this work.

1. Field Supervisor Qualifications: Full-time supervisors experienced in specialty work similar in nature, material, design, and extent to that indicated for this Project. Supervisors shall be on-site when specialty work begins and during its progress. Supervisors shall not be changed during Project except for causes beyond the control of the specialist firm.

a. Construct new mockups of required work whenever a supervisor is replaced.

B. Title X Requirement: Each firm conducting activities that disturb painted surfaces shall be a "Lead-Safe Certified Firm" according to 40 CFR 745, Subpart E, and use only workers that are trained in lead-safe work practices.

C. Alteration Work Program: Prepare a written plan for alteration work for whole Project, including each phase or process and protection of surrounding materials during operations. Show compliance with indicated methods and procedures specified in this and other Sections. Coordinate this whole-Project alteration work program with specific requirements of programs required in other alteration work Sections.

1. Dust and Noise Control: Include locations of proposed temporary dust- and noise-control partitions and means of egress from occupied areas coordinated with continuing on-site operations and other known work in progress.
2. Debris Hauling: Include plans clearly marked to show debris hauling routes, turning radii, and locations and details of temporary protective barriers.

D. Fire-Prevention Plan: Prepare a written plan for preventing fires during the Work, including placement of fire extinguishers, fire blankets, rag buckets, and other fire-control devices during each phase or process. Coordinate plan with Owner's fire-protection equipment and requirements. Include fire-watch personnel's training, duties, and authority to enforce fire safety.

E. Safety and Health Standard: Comply with ANSI/ASSE A10.6.

1.8 STORAGE AND HANDLING OF SALVAGED MATERIALS

A. Salvaged Materials for Reinstallation:

1. Repair and clean items for reuse as indicated.
2. Pack or crate items after cleaning and repairing; cushion against damage during handling. Label 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 unless otherwise indicated. Provide connections, supports, and miscellaneous materials to make items functional for use indicated.

B. Existing Materials to Remain: Protect construction indicated to remain against damage and soiling from construction work. Where permitted by Architect, items may be dismantled and taken to a suitable, protected storage location during construction work and reinstalled in their original locations after alteration and other construction work in the vicinity is complete.

C. Storage: Catalog and store items within a weathertight enclosure where they are protected from moisture, weather, condensation, and freezing temperatures.

1. Identify each item for reinstallation with a nonpermanent mark to document its original location. Indicate original locations on plans, elevations, sections, or photographs by annotating the identifying marks.
2. Secure stored materials to protect from theft.
3. Control humidity so that it does not exceed 85 percent. Maintain temperatures 5 deg F or more above the dew point.

D. Storage Space:

1. Owner will arrange for limited on-site location(s) for free storage of salvaged material. This storage space does not include security and climate control for stored material.

1.9 FIELD CONDITIONS

A. Survey of Existing Conditions: Record existing conditions that affect the Work by use of measured drawings and preconstruction photographs .

1. Comply with requirements specified in Section 013233 "Photographic Documentation."

B. Discrepancies: Notify Architect of discrepancies between existing conditions and Drawings before proceeding with removal and dismantling work.

C. Owner's Removals: Before beginning alteration work, verify in correspondence with Owner that the following items have been removed:

1. Laboratory equipment..

PART 2 - PRODUCTS - (Not Used)

PART 3 - EXECUTION

3.1 PROTECTION

A. Protect persons, motor vehicles, surrounding surfaces of building, building site, plants, and surrounding buildings from harm resulting from alteration work.

1. Use only proven protection methods, appropriate to each area and surface being protected.
2. Provide temporary barricades, barriers, and directional signage to exclude the public from areas where alteration work is being performed.
3. Erect temporary barriers to form and maintain fire-egress routes.
4. Erect temporary protective covers over walkways and at points of pedestrian and vehicular entrance and exit that must remain in service during alteration work.
5. Contain dust and debris generated by alteration work, and prevent it from reaching the public or adjacent surfaces.
6. Provide shoring, bracing, and supports as necessary. Do not overload structural elements.
7. Protect floors and other surfaces along hauling routes from damage, wear, and staining.
8. Provide supplemental sound-control treatment to isolate demolition work from other areas of the building.

B. Temporary Protection of Materials to Remain:

1. Protect existing materials with temporary protections and construction. Do not remove existing materials unless otherwise indicated.
2. Do not attach temporary protection to existing surfaces except as indicated as part of the alteration work program.

C. Comply with each product manufacturer's written instructions for protections and precautions. Protect against adverse effects of products and procedures on people and adjacent materials, components, and vegetation.

D. Utility and Communications Services:

1. Notify Owner, Architect, authorities having jurisdiction, and entities owning or controlling wires, conduits, pipes, and other services affected by alteration work before commencing operations.
2. Disconnect and cap pipes and services as required by authorities having jurisdiction, as required for alteration work.
3. Maintain existing services unless otherwise indicated; keep in service, and protect against damage during operations. Provide temporary services during interruptions to existing utilities.

E. Existing Drains: Prior to the start of 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 work in an area until the drainage system is functioning properly.

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

3.2 PROTECTION FROM FIRE

A. General: Follow fire-prevention plan and the following:

1. Comply with NFPA 241 requirements unless otherwise indicated. Perform duties titled "Owner's Responsibility for Fire Protection."
2. Remove and keep area free of combustibles, including rubbish, paper, waste, and chemicals, unless necessary for the immediate work.

    a. If combustible material cannot be removed, provide fire blankets to cover such materials.

B. Heat-Generating Equipment and Combustible Materials: Comply with the following procedures while performing work with heat-generating equipment or combustible materials, including welding, torch-cutting, soldering, brazing, removing paint with heat, or other operations where open flames or implements using high heat or combustible solvents and chemicals are anticipated:

1. Obtain Owner's approval for operations involving use of welding or other high-heat equipment. Use of open-flame equipment is not permitted. Notify Owner at least 72 hours before each occurrence, indicating location of such work.
2. As far as practicable, restrict heat-generating equipment to shop areas or outside the building.
3. Do not perform work with heat-generating equipment in or near rooms or in areas where flammable liquids or explosive vapors are present or thought to be present. Use a combustible gas indicator test to ensure that the area is safe.
4. Use fireproof baffles to prevent flames, sparks, hot gases, or other high-temperature material from reaching surrounding combustible material.
5. Prevent the spread of sparks and particles of hot metal through open windows, doors, holes, and cracks in floors, walls, ceilings, roofs, and other openings.
6. Fire Watch: Before working with heat-generating equipment or combustible materials, station personnel to serve as a fire watch at each location where such work is performed. Fire-watch personnel shall have the authority to enforce fire safety. Station fire watch according to NFPA 51B, NFPA 241, and as follows:

    a. Train each fire watch in the proper operation of fire-control equipment and alarms.
    b. Prohibit fire-watch personnel from other work that would be a distraction from fire-watch duties.
    c. Cease work with heat-generating equipment whenever fire-watch personnel are not present.
    d. Have fire-watch personnel perform final fire-safety inspection each day beginning no sooner than 30 minutes after conclusion of work in each area to detect hidden or smoldering fires and to ensure that proper fire prevention is maintained.
    e. Maintain fire-watch personnel at each area of Project site until two hours after conclusion of daily work.

C. Fire-Control Devices: Provide and maintain fire extinguishers, fire blankets, and rag buckets for disposal of rags with combustible liquids. Maintain each as suitable for the type of fire risk in each work area. Ensure that nearby personnel and the fire-watch personnel are trained in fire-extinguisher and blanket use.

D. Sprinklers: Where sprinkler protection exists and is functional, maintain it without interruption while operations are being performed. If operations are performed close to sprinklers, shield them temporarily with guards.

1. Remove temporary guards at the end of work shifts, whenever operations are paused, and when nearby work is complete.

3.3 PROTECTION DURING APPLICATION OF CHEMICALS

A. Protect motor vehicles, surrounding surfaces of building, building site, plants, and surrounding buildings from harm or spillage resulting from applications of chemicals and adhesives.

B. Cover adjacent surfaces with protective materials that are proven to resist chemicals selected for Project unless chemicals being used will not damage adjacent surfaces as indicated in alteration work program. Use covering materials and masking agents that are waterproof and UV resistant and that will not stain or leave residue on surfaces to which they are applied. Apply protective materials according to manufacturer's written instructions. Do not apply liquid masking agents or adhesives to painted or porous surfaces. When no longer needed, promptly remove protective materials.

C. Do not apply chemicals during winds of sufficient force to spread them to unprotected surfaces.

D. Neutralize alkaline and acid wastes and legally dispose of off Owner's property.

E. Collect and dispose of runoff from chemical operations by legal means and in a manner that prevents soil contamination, soil erosion, undermining of paving and foundations, damage to landscaping, or water penetration into building interior.

3.4 GENERAL ALTERATION WORK

A. Have specialty work performed only by qualified specialists.

B. Ensure that supervisory personnel are present when work begins and during its progress.

C. Record existing work before each procedure (preconstruction), and record progress during the work. Use digital preconstruction documentation photographs. Comply with requirements in Section 013233 "Photographic Documentation."

D. Perform surveys of Project site as the Work progresses to detect hazards resulting from alterations.

E. Notify Architect of visible changes in the integrity of material or components whether from environmental causes including biological attack, UV degradation, freezing, or thawing or from structural defects including cracks, movement, or distortion.

1. Do not proceed with the work in question until directed by Architect.

END OF SECTION 013516

SECTION 014000 - QUALITY REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. 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. Specific quality-assurance and quality-control requirements for individual work results are specified in their respective Specification Sections. Requirements in individual Sections may also cover production of standard products.
2. 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.
3. Requirements for Contractor to provide quality-assurance and quality-control services required by Architect, Owner, Commissioning Authority, or authorities having jurisdiction are not limited by provisions of this Section. Commissioning provided by consultant to the Owner.
4. Specific test and inspection requirements are not specified in this Section.

C. Related Requirements:

1. Section 012100 "Allowances" for testing and inspection allowances.

1.3 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: 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 trade or entity does not require that certain construction activities be performed by accredited or unionized individuals, or that requirements specified apply exclusively to specific trade(s).

D. Mockups: Full-size physical assemblies that are constructed on-site either as freestanding temporary built elements or as part of permanent construction. Mockups are constructed to verify selections made under Sample submittals; to demonstrate aesthetic effects and qualities of materials and execution; to review coordination, testing, or operation; to show interface between dissimilar materials; and to demonstrate compliance with specified installation tolerances. Mockups are not Samples. Unless otherwise indicated, approved mockups establish the standard by which the Work will be judged.

1. Laboratory Mockups: Full-size physical assemblies constructed and tested at testing facility to verify performance characteristics.
2. Integrated Exterior Mockups: Mockups of the exterior envelope constructed on-site as freestanding temporary built elements or as part of permanent construction, consisting of multiple products, assemblies, and subassemblies.
3. Room Mockups: Mockups of typical interior spaces complete with wall, floor, and ceiling finishes; doors; windows; millwork; casework; specialties; furnishings and equipment; and lighting.

E. 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.

F. 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.

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

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

I. 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.

J. 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 Architect.

1.4 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 Architect.

1.5 CONFLICTING REQUIREMENTS

A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements are specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, comply with the most stringent requirement. Refer conflicting requirements that are different, but apparently equal, to Architect for direction before proceeding.

B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified shall be the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Architect for a decision before proceeding.

1.6 ACTION SUBMITTALS

A. Shop Drawings: For mockups.

1. Include plans, sections, and elevations, indicating materials and size of mockup construction.
2. Indicate manufacturer and model number of individual components.
3. Provide axonometric drawings for conditions difficult to illustrate in two dimensions.

B. Delegated-Design Services Submittal: In addition to Shop Drawings, Product Data, and other required submittals, 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.

1.7 INFORMATIONAL SUBMITTALS

A. Contractor's Quality-Control Plan: For quality-assurance and quality-control activities and responsibilities.

B. Qualification Data: For Contractor's quality-control personnel.

C. 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.

D. Schedule of Tests and Inspections: Prepare in tabular form and include the following:

1. Specification Section number and title.
2. Entity responsible for performing tests and inspections.
3. Description of test and inspection.
4. Identification of applicable standards.
5. Identification of test and inspection methods.
6. Number of tests and inspections required.
7. Time schedule or time span for tests and inspections.
8. Requirements for obtaining samples.
9. Unique characteristics of each quality-control service.

E. Reports: Prepare and submit certified written reports and documents as specified.

F. 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.

1.8 CONTRACTOR'S QUALITY-CONTROL PLAN

A. Quality-Control Plan, General: Submit quality-control plan within 10 days of Notice to Proceed, and not less than five days prior to preconstruction conference. Submit in format acceptable to Architect. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-assurance and quality-control responsibilities. Coordinate with Contractor's Construction Schedule.

B. Quality-Control Personnel Qualifications: Engage qualified personnel trained and experienced in managing and executing quality-assurance and quality-control procedures similar in nature and extent to those required for Project.

1. Project quality-control manager may also serve as Project superintendent.

C. Submittal Procedure: Describe procedures for ensuring compliance with requirements through review and management of submittal process. Indicate qualifications of personnel responsible for submittal review.

D. Testing and Inspection: In quality-control plan, include a comprehensive schedule of Work requiring testing or inspection, including the following:

1. Contractor-performed tests and inspections including Subcontractor-performed tests and inspections. Include required tests and inspections and Contractor-elected tests and inspections. Distinguish source quality-control tests and inspections from field quality-control tests and inspections.
2. Owner-performed tests and inspections indicated in the Contract Documents, including tests and inspections indicated to be performed by Commissioning Authority. Commissioning agent provided by consultant to the Owner; Contractor responsible for all tests/inspections and Commissioning tests/ inspections

E. Continuous Inspection of Workmanship: Describe process for continuous inspection during construction to identify and correct deficiencies in workmanship in addition to testing and inspection specified. Indicate types of corrective actions to be required to bring work into compliance with standards of workmanship established by Contract requirements and approved mockups.

F. Monitoring and Documentation: Maintain testing and inspection reports including log of approved and rejected results. Include work Architect has indicated as nonconforming or defective. Indicate corrective actions taken to bring nonconforming work into compliance with requirements. Comply with requirements of authorities having jurisdiction.

1.9 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. Name, address, telephone number, and email address of technical representative making report.
2. Statement on condition of substrates and their acceptability for installation of product.
3. Statement that products at Project site comply with requirements.
4. Summary of installation procedures being followed, whether they comply with requirements and, if not, what corrective action was taken.
5. Results of operational and other tests and a statement of whether observed performance complies with requirements.
6. Statement whether conditions, products, and installation will affect warranty.
7. 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. Name, address, telephone number, and email address of factory-authorized service representative making report.
2. Statement that equipment complies with requirements.
3. Results of operational and other tests and a statement of whether observed performance complies with requirements.
4. Statement whether conditions, products, and installation will affect warranty.
5. Other required items indicated in individual Specification Sections.

1.10 QUALITY ASSURANCE

A. General: 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. Testing 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 E 329; and with additional qualifications specified in individual Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.

G. 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.

H. Factory-Authorized Service Representative Qualifications: An authorized representative of manufacturer who is trained and approved by manufacturer to inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

1.11 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. Payment for these services will be made from testing and inspection allowances, as authorized by Change Orders.
3. Costs for retesting and reinspecting construction that replaces or is necessitated by work that failed to comply with the Contract Documents will be charged to Contractor.

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. Unless otherwise indicated, provide quality-control services specified and those required by authorities having jurisdiction. Perform quality-control services required of Contractor by authorities having jurisdiction, whether specified or not.
2. 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.

3. Notify testing agencies at least 24 hours in advance of time when Work that requires testing or inspection will be performed.
4. Where quality-control services are indicated as Contractor's responsibility, submit a certified written report, in duplicate, of each quality-control service.
5. Testing and inspection requested by Contractor and not required by the Contract Documents are Contractor's responsibility.
6. 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 Architect, Commissioning Authority and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.

1. Notify Architect, 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. Associated Contractor 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. Delivery of samples to testing agencies.
6. Preliminary design mix proposed for use for material mixes that require control by testing agency.
7. Security and protection for samples and for testing and 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.

I. Schedule of Tests and Inspections: Prepare a schedule of tests, inspections, and similar quality-control services required by the Contract Documents as a component of Contractor's quality-control plan. Coordinate and submit concurrently with Contractor's Construction Schedule. Update as the Work progresses.

1. Distribution: Distribute schedule to Owner, Architect, Commissioning Authority, testing agencies, and each party involved in performance of portions of the Work where tests and inspections are required.

1.12 SPECIAL TESTS AND INSPECTIONS

A. Special Tests and Inspections: 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 Architect, 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 Architect 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 reinspecting corrected work.
7. .

B. Special Tests and Inspections: Conducted by a qualified testing agency as required by authorities having jurisdiction, as indicated in individual Specification Sections, 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 Architect, 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 Architect 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 reinspecting 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 Architect.
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 Architect's, Commissioning Authority's, 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 RELATED DOCUMENTS

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

1.2 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.

1.3 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.

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.

1.4 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 Safety Engineers (The); www.asse.org.
34. ASSE - American Society of Sanitary Engineering; www.asse-plumbing.org.
35. ASTM - ASTM International; www.astm.org.
36. ATIS - Alliance for Telecommunications Industry Solutions; www.atis.org.
37. AWEA - American Wind Energy Association; www.awea.org.
38. AWI - Architectural Woodwork Institute; www.awinet.org.
39. AWMAC - Architectural Woodwork Manufacturers Association of Canada; www.awmac.com.
40. AWPA - American Wood Protection Association; www.awpa.com.
41. AWS - American Welding Society; www.aws.org.
42. AWWA - American Water Works Association; www.awwa.org.
43. BHMA - Builders Hardware Manufacturers Association; www.buildershardware.com.
44. BIA - Brick Industry Association (The); www.gobrick.com.
45. BICSI - BICSI, Inc.; www.bicsi.org.
46. BIFMA - BIFMA International; (Business and Institutional Furniture Manufacturer's Association); www.bifma.org.
47. BISSC - Baking Industry Sanitation Standards Committee; www.bissc.org.
48. BWF - Badminton World Federation; (Formerly: International Badminton Federation); www.bissc.org.
49. CDA - Copper Development Association; www.copper.org.
50. CE - Conformite Europeenne; http://ec.europa.eu/growth/single-market/ce-marking/.
51. CEA - Canadian Electricity Association; www.electricity.ca.
52. CEA - Consumer Electronics Association; www.ce.org.
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.pbmdf.com.
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.csagroup.com.
65. CSA - CSA International; www.csa-international.org.
66. CSI - Construction Specifications Institute (The); www.csinet.org.
67. CSSB - Cedar Shake & Shingle Bureau; www.cedarbureau.org.
68. CTI - Cooling Technology Institute; (Formerly: Cooling Tower Institute); www.cti.org.
69. CWC - Composite Wood Council; (See CPA).
70. DASMA - Door and Access Systems Manufacturers Association; www.dasma.com.

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

116. ISFA - International Surface Fabricators Association; (Formerly: International Solid Surface Fabricators Association); www.isfanow.org.
117. ISO - International Organization for Standardization; www.iso.org.
118. ISSFA - International Solid Surface Fabricators Association; (See ISFA).
119. ITU - International Telecommunication Union; www.itu.int/home.
120. KCMA - Kitchen Cabinet Manufacturers Association; www.kcma.org.
121. LMA - Laminating Materials Association; (See CPA).
122. LPI - Lightning Protection Institute; www.lightning.org.
123. MBMA - Metal Building Manufacturers Association; www.mbma.com.
124. MCA - Metal Construction Association; www.metalconstruction.org.
125. MFMA - Maple Flooring Manufacturers Association, Inc.; www.maplefloor.org.
126. MFMA - Metal Framing Manufacturers Association, Inc.; www.metalframingmfg.org.
127. MHIA - Material Handling Industry of America; www.mhia.org.
128. MIA - Marble Institute of America; www.marble-institute.com.
129. MMPA - Moulding & Millwork Producers Association; www.wmmpa.com.
130. MPI - Master Painters Institute; www.paintinfo.com.
131. MSS - Manufacturers Standardization Society of The Valve and Fittings Industry Inc.; www.mss-hq.org.
132. NAAMM - National Association of Architectural Metal Manufacturers; www.naamm.org.
133. NACE - NACE International; (National Association of Corrosion Engineers International); www.nace.org.
134. NADCA - National Air Duct Cleaners Association; www.nadca.com.
135. NAIMA - North American Insulation Manufacturers Association; www.naima.org.
136. NBGQA - National Building Granite Quarries Association, Inc.; www.nbgqa.com.
137. NBI - New Buildings Institute; www.newbuildings.org.
138. NCAA - National Collegiate Athletic Association (The); www.ncaa.org.
139. NCMA - National Concrete Masonry Association; www.ncma.org.
140. NEBB - National Environmental Balancing Bureau; www.nebb.org.
141. NECA - National Electrical Contractors Association; www.necanet.org.
142. NeLMA - Northeastern Lumber Manufacturers Association; www.nelma.org.
143. NEMA - National Electrical Manufacturers Association; www.nema.org.
144. NETA - InterNational Electrical Testing Association; www.netaworld.org.
145. NFHS - National Federation of State High School Associations; www.nfhs.org.
146. NFPA - National Fire Protection Association; www.nfpa.org.
147. NFPA - NFPA International; (See NFPA).
148. NFRC - National Fenestration Rating Council; www.nfrc.org.
149. NHLA - National Hardwood Lumber Association; www.nhla.com.
150. NLGA - National Lumber Grades Authority; www.nlga.org.
151. NOFMA - National Oak Flooring Manufacturers Association; (See NWFA).
152. NOMMA - National Ornamental & Miscellaneous Metals Association; www.nomma.org.
153. NRCA - National Roofing Contractors Association; www.nrca.net.
154. NRMCA - National Ready Mixed Concrete Association; www.nrmca.org.
155. NSF - NSF International; www.nsf.org.
156. NSPE - National Society of Professional Engineers; www.nspe.org.
157. NSSGA - National Stone, Sand & Gravel Association; www.nssga.org.
158. NTMA - National Terrazzo & Mosaic Association, Inc. (The); www.ntma.com.
159. NWFA - National Wood Flooring Association; www.nwfa.org.
160. PCI - Precast/Prestressed Concrete Institute; www.pci.org.
161. PDI - Plumbing & Drainage Institute; www.pdionline.org.
162. PLASA - PLASA; (Formerly: ESTA - Entertainment Services and Technology Association); www.plasa.org.
163. RCSC - Research Council on Structural Connections; www.boltcouncil.org.
164. RFCI - Resilient Floor Covering Institute; www.rfci.com.

165. RIS - Redwood Inspection Service; www.redwoodinspection.com.
166. SAE - SAE International; www.sae.org.
167. SCTE - Society of Cable Telecommunications Engineers; www.scte.org.
168. SDI - Steel Deck Institute; www.sdi.org.
169. SDI - Steel Door Institute; www.steeldoor.org.
170. SEFA - Scientific Equipment and Furniture Association (The); www.sefalabs.com.
171. SEI/ASCE - Structural Engineering Institute/American Society of Civil Engineers; (See ASCE).
172. SIA - Security Industry Association; www.siaonline.org.
173. SJI - Steel Joist Institute; www.steeljoist.org.
174. SMA - Screen Manufacturers Association; www.smainfo.org.
175. SMACNA - Sheet Metal and Air Conditioning Contractors' National Association; www.smacna.org.
176. SMPTE - Society of Motion Picture and Television Engineers; www.smpte.org.
177. SPFA - Spray Polyurethane Foam Alliance; www.sprayfoam.org.
178. SPIB - Southern Pine Inspection Bureau; www.spib.org.
179. SPRI - Single Ply Roofing Industry; www.spri.org.
180. SRCC - Solar Rating & Certification Corporation; www.solar-rating.org.
181. SSINA - Specialty Steel Industry of North America; www.ssina.com.
182. SSPC - SSPC: The Society for Protective Coatings; www.sspc.org.
183. STI - Steel Tank Institute; www.steeltank.com.
184. SWI - Steel Window Institute; www.steelwindows.com.
185. SWPA - Submersible Wastewater Pump Association; www.swpa.org.
186. TCA - Tilt-Up Concrete Association; www.tilt-up.org.
187. TCNA - Tile Council of North America, Inc.; www.tileusa.com.
188. TEMA - Tubular Exchanger Manufacturers Association, Inc.; www.tema.org.
189. TIA - Telecommunications Industry Association (The); (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance); www.tiaonline.org.
190. TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance; (See TIA).
191. TMS - The Masonry Society; www.masonrysociety.org.
192. TPI - Truss Plate Institute; www.tpinst.org.
193. TPI - Turfgrass Producers International; www.turfgrasssod.org.
194. TRI - Tile Roofing Institute; www.tileroofing.org.
195. UL - Underwriters Laboratories Inc.; www.ul.com.
196. UNI - Uni-Bell PVC Pipe Association; www.uni-bell.org.
197. USAV - USA Volleyball; www.usavolleyball.org.
198. USGBC - U.S. Green Building Council; www.usgbc.org.
199. USITT - United States Institute for Theatre Technology, Inc.; www.usitt.org.
200. WA - Wallcoverings Association; www.wallcoverings.org.
201. WASTEC - Waste Equipment Technology Association; www.wastec.org.
202. WCLIB - West Coast Lumber Inspection Bureau; www.wclib.org.
203. WCMA - Window Covering Manufacturers Association; www.wcmanet.org.
204. WDMA - Window & Door Manufacturers Association; www.wdma.com.
205. WI - Woodwork Institute; www.wicnet.org.
206. WSRCA - Western States Roofing Contractors Association; www.wsrca.com.
207. WWPA - Western Wood Products Association; www.wwpa.org.

C. Code 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 believed to be accurate as of the date of the Contract Documents.

1. DIN - Deutsches Institut fur Normung e.V.; www.din.de.

2. IAPMO - International Association of Plumbing and Mechanical Officials; www.iapmo.org.
3. ICC - International Code Council; www.iccsafe.org.
4. ICC-ES - ICC Evaluation Service, LLC; www.icc-es.org.

D. 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.

E. 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.gpo.gov/fdsys.
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).

F. 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. CBHF; State of California; Department of Consumer Affairs; Bureau of Electronic and Appliance Repair, Home Furnishings and Thermal Insulation; www.bearhfti.ca.gov.
2. CCR; California Code of Regulations; Office of Administrative Law; California Title 24 Energy Code; www.calregs.com.
3. CDHS; California Department of Health Services; (See CDPH).
4. CDPH; California Department of Public Health; Indoor Air Quality Program; www.cal-iaq.org.
5. CPUC; California Public Utilities Commission; www.cpuc.ca.gov.
6. SCAQMD; South Coast Air Quality Management District; www.aqmd.gov.
7. TFS; Texas A&M Forest Service; Sustainable Forestry and Economic Development; www.txforestservice.tamu.edu.

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 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes 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.

1.3 USE CHARGES

A. General: Installation and removal of 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, Architect, 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.

1.4 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. Moisture- and Mold-Protection Plan: Describe procedures and controls for protecting materials and construction from water absorption and damage and mold.

D. Dust- and HVAC-Control Plan: Submit coordination drawing and narrative that indicates the dust- and HVAC-control measures proposed for use, proposed locations, and proposed time frame for their operation. Include the following:

1. Locations of dust-control partitions at each phase of work.
2. HVAC system isolation schematic drawing.
3. Location of proposed air-filtration system discharge.
4. Waste-handling procedures.
5. Other dust-control measures.

1.5 QUALITY ASSURANCE

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

1.6 PROJECT CONDITIONS

A. Temporary Use of Permanent Facilities: Engage Installer of each permanent service to assume responsibility for operation, maintenance, and protection of each permanent service during its use as a construction facility before Owner's acceptance, regardless of previously assigned responsibilities.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Portable Chain-Link Fencing: Minimum 2-inch, 0.148-inch- thick, galvanized-steel, chain-link fabric fencing; minimum 6 feet high with galvanized-steel pipe posts; minimum 2-3/8-inch- OD line posts and 2-7/8-inch- OD corner and pull posts, with 1-5/8-inch- OD top and bottom rails. Provide concrete bases for supporting posts.

B. Fencing Windscreen Privacy Screen: Polyester fabric scrim with grommets for attachment to chain link fence, sized to height of fence, in color selected by Architect from manufacturer's standard colors.

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. Permanent HVAC System: If Owner authorizes use of permanent HVAC system for temporary use during construction, provide filter with MERV of 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.

1. Locate facilities to limit site disturbance as specified in Section 011000 "Summary."

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 TEMPORARY UTILITY INSTALLATION

A. Water Service: Connect to Owner's existing water service facilities. Clean and maintain water service facilities in a condition acceptable to Owner. At Substantial Completion, restore these facilities to condition existing before initial use.

B. Sanitary Facilities: Provide temporary toilets, wash facilities, and drinking water for use of construction personnel. Comply with requirements of authorities having jurisdiction for type, number, location, operation, and maintenance of fixtures and facilities.

1. Toilets: Use of Owner's existing toilet facilities will be permitted, as long as facilities are cleaned and maintained in a condition acceptable to Owner. At Substantial Completion, restore these facilities to condition existing before initial use.

C. Temporary Heating and Cooling: Provide temporary heating and cooling required by construction activities for curing or drying of completed installations or for protecting installed construction from adverse effects of low temperatures or high humidity. Select equipment that will not have a harmful effect on completed installations or elements being installed.

1. Provide temporary dehumidification systems when required to reduce ambient and substrate moisture levels to level required to allow installation or application of finishes and their proper curing or drying.

D. Isolation of Work Areas within Building: Prevent dust, fumes, and odors from entering areas outside the Scope of Work.

1. Prior to commencing work, isolate the HVAC system in area where work is to be performed according to coordination drawings.

    a. Disconnect supply and return ductwork in work area from HVAC systems servicing occupied areas.
    b. Maintain negative air pressure within work area using HEPA-equipped air-filtration units, starting with commencement of temporary partition construction, and continuing until removal of temporary partitions is complete.

2. Maintain dust partitions during the Work. Use vacuum collection attachments on dust-producing equipment. Isolate limited work within occupied areas using portable dust-containment devices.
3. Perform daily construction cleanup and final cleanup using approved, HEPA-filter-equipped vacuum equipment.

E. Electric Power Service: Connect to Owner's existing electric power service. Maintain equipment in a condition acceptable to Owner.

F. Telephone Service: Provide temporary telephone service in common-use facilities for use by all construction personnel. Install WiFi cell phone access equipment land-based telephone line(s) for each field office.

1. Provide additional telephone lines for the following:

    a. Provide one telephone line(s) for Owner's use.

2. At each telephone, post a list of important telephone numbers.

    a. Police and fire departments.
    b. Ambulance service.
    c. Contractor's home office.
    d. Contractor's emergency after-hours telephone number.
    e. Architect's office.
    f.
    g. Engineers' offices.
    h. Owner's office.
    i. Principal subcontractors' field and home offices.

G. Electronic Communication Service: Provide a desktop computer in the primary field office adequate for use by Architect and Owner to access Project electronic documents and maintain electronic communications. Equip computer with not less than the following:

1. Processor: Intel Core i5 or i7.
2. Memory: 4 gigabyte.
3. Disk Storage: 500 gigabyte hard-disk drive and combination DVD-RW/CD-RW drive.

4. Display: 24-inch LCD monitor with 256-Mb dedicated video RAM.
5. Full-size keyboard and mouse.
6. Network Connectivity: 10/100BaseT Ethernet.
7. Operating System: Microsoft Windows 7 Professional.
8. Productivity Software:

    a. Microsoft Office Professional, 2010 or higher, including Word, Excel, and Outlook.
    b. Adobe Reader 11.0 or higher.
    c. WinZip 7.0 or higher.

9. Printer: "All-in-one" unit equipped with printer server, combining color printing, photocopying, scanning, and faxing, or separate units for each of these three functions.
10. Internet Service: Broadband modem, router and ISP, equipped with hardware firewall, providing minimum 1.0 Mbps upload and 15 Mbps download speeds at each computer.
11. Internet Security: Integrated software, providing software firewall, virus, spyware, phishing, and spam protection in a combined application.
12. Backup: External hard drive, minimum 2 terabyte, with automated backup software providing daily backups.

3.4 SUPPORT FACILITIES INSTALLATION

A. General: Comply with the following:

1. Provide construction for temporary offices, shops, and sheds located within construction area or within 30 feet of building lines that is noncombustible according to ASTM E 136. Comply with NFPA 241.
2. Maintain support facilities until Architect schedules Substantial Completion inspection. Remove before Substantial Completion. Personnel remaining after Substantial Completion will be permitted to use permanent facilities, under conditions acceptable to Owner.

B. 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.

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

D. Project Signs: Provide Project signs as indicated. Unauthorized signs are not permitted.

1. Identification Signs: Provide Project identification signs as indicated on Drawings.
2. Temporary Signs: Provide other signs as indicated and as required to inform public and individuals seeking entrance to Project.

    a. Provide temporary, directional signs for construction personnel and visitors.

3. Maintain and touch up signs so they are legible at all times.

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

F. 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.

G. 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.

3.5 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.

1. Comply with work restrictions specified in Section 011000 "Summary."

C. Tree and Plant Protection: Install temporary fencing located as indicated or outside the drip line of trees to protect vegetation from damage from construction operations. Protect tree root systems from damage, flooding, and erosion.

D. Pest Control: Engage pest-control service to recommend practices to minimize attraction and harboring of rodents, roaches, and other pests and to perform extermination and control procedures at regular intervals so Project will be free of pests and their residues at Substantial Completion. Perform control operations lawfully, using materials approved by authorities having jurisdiction.

E. Site Enclosure Fence: Before construction operations begin, furnish and install site enclosure fence in a manner that will prevent people from easily entering site except by entrance gates.

1. Extent of Fence: As required to enclose entire Project site or portion determined sufficient to accommodate construction operations.
2. Maintain security by limiting number of keys and restricting distribution to authorized personnel. Furnish one set of keys to Owner.

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

G. Temporary Egress: Maintain temporary egress from existing occupied facilities as indicated and as required by authorities having jurisdiction.

H. Covered Walkway: Erect protective, covered walkway for passage of individuals through or adjacent to Project site. Coordinate with entrance gates, other facilities, and obstructions. Comply with regulations of authorities having jurisdiction.

1. Provide overhead decking, protective enclosure walls, handrails, barricades, warning signs, exit signs, lights, safe and well-drained walkways, and similar provisions for protection and safe passage.
2. Paint and maintain appearance of walkway for duration of the Work.

I. 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.

J. Temporary Partitions: Provide floor-to-ceiling dustproof partitions to limit dust and dirt migration and to separate areas outside of the rom fumes and noise.

1. Construct dustproof partitions with two layers of 6-mil polyethylene sheet on each side. Cover floor with two layers of 6-mil polyethylene sheet, extending sheets 18 inches up the sidewalls. Overlap and tape full length of joints. Cover floor with fire-retardant-treated plywood.

    a. Construct vestibule and airlock at each entrance through temporary partition with not less than 48 inches between doors. Maintain water-dampened foot mats in vestibule.

2. Seal joints and perimeter. Equip partitions with gasketed dustproof doors and security locks where openings are required.
3. Protect air-handling equipment.
4. Provide walk-off mats at each entrance through temporary partition.

K. 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.

3.6 MOISTURE AND MOLD CONTROL

A. Contractor's Moisture-Protection Plan: 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 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.

B. Exposed Construction Period: Before installation of weather barriers, when materials are subject to wetting and exposure and to airborne mold spores, protect as follows:

1. Protect porous materials from water damage.
2. Protect stored and installed material from flowing or standing water.
3. Keep porous and organic materials from coming into prolonged contact with concrete.
4. Remove standing water from decks.
5. Keep deck openings covered or dammed.

3.7 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 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for 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 012300 "Alternates" for products selected under an alternate.
2. Section 012500 "Substitution Procedures" for requests for substitutions.
3. Section 014200 "References" for applicable industry standards for products specified.

1.3 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. Products salvaged or recycled from other projects are not considered new products.
3. Comparable Product: Product that is demonstrated and approved by Architect through submittal process 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. 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.

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, if applicable.

1.4 ACTION SUBMITTALS

A. Comparable Product Request Submittal: Submit request for consideration of each comparable product. Identify basis-of-design product or fabrication or installation method to be replaced. Include Specification Section number and title and Drawing numbers and titles.

1. Include data to indicate compliance with the requirements specified in "Comparable Products" Article.
2. Architect's Action: If necessary, Architect will request additional information or documentation for evaluation within seven days of receipt of a comparable product request. Architect will notify Contractor of approval or rejection of proposed comparable product request within 15 days of receipt of request, or seven days of receipt of additional information or documentation, whichever is later.

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

B. Basis-of-Design Product Specification Submittal: Comply with requirements in Section 013300 "Submittal Procedures." Show compliance with requirements.

1.5 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. Each contractor is responsible for providing products and construction methods compatible with products and construction methods of other contractors.
2. If a dispute arises between contractors over concurrently selectable but incompatible products, Architect will determine which products shall be used.

B. Identification of Products: Except for required labels and operating data, do not attach or imprint manufacturer or product names or trademarks on exposed surfaces of products or equipment that will be exposed to view in occupied spaces or on the exterior.

1. Labels: Locate required product labels and stamps on a concealed surface, or, where required for observation following installation, on a visually accessible surface that is not conspicuous.

2. Equipment Nameplates: Provide a permanent nameplate on each item of service-connected or power-operated equipment. Locate on a visually accessible but inconspicuous surface. Include information essential for operation, including the following:

    a. Name of product and manufacturer.
    b. Model and serial number.
    c. Capacity.
    d. Speed.
    e. Ratings.

3. See individual identification sections in Divisions 21, 22, 23, and 26 for additional identification requirements.

1.6 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.

B. Delivery and Handling:

1. Schedule delivery to minimize long-term storage at Project site and to prevent overcrowding of construction spaces.
2. Coordinate delivery with installation time to ensure minimum holding time for items that are flammable, hazardous, easily damaged, or sensitive to deterioration, theft, and other losses.
3. Deliver products to Project site in an undamaged condition in manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing.
4. Inspect products on delivery to determine compliance with the Contract Documents and to determine that products are undamaged and properly protected.

C. Storage:

1. Store products to allow for inspection and measurement of quantity or counting of units.
2. Store materials in a manner that will not endanger Project structure.
3. Store products that are subject to damage by the elements, under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation.
4. Protect foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
5. Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.
6. Protect stored products from damage and liquids from freezing.
7. Provide a secure location and enclosure at Project site for storage of materials and equipment by Owner's construction forces. Coordinate location with Owner.

1.7 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 warranty furnished by individual manufacturer for a particular product and specifically endorsed by manufacturer to Owner.
2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for 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 with the Specifications, prepare a written document using indicated form properly executed.
3. See other Sections for specific content requirements and particular requirements for submitting special warranties.

C. Submittal Time: Comply with requirements in Section 017700 "Closeout Procedures."

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," Architect will make selection.
5. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.

B. Product Selection Procedures:

1. 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 be considered.

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

2. 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 be considered.

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

3. 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 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.

2.2 COMPARABLE PRODUCTS

A. Conditions for Consideration of Comparable Products: Architect will consider Contractor's request for comparable product when the following conditions are satisfied with no increase in cost to the Project. If the following conditions are not satisfied, Architect may return requests without action, except to record noncompliance with these 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. Detailed comparison of significant qualities of proposed product with those named in the Specifications. 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.
2. Evidence that proposed product provides specified warranty.
3. List of similar installations for completed projects with project names and addresses and names and addresses of architects and owners, if requested.
4. Samples, if requested.

B. Submittal Requirements: Approval by the Architect of Contractor's request for use of comparable product is not intended to satisfy other submittal requirements. Comply with specified submittal requirements.

PART 3 - EXECUTION (Not Used)

END OF SECTION 016000

SECTION 017300 - EXECUTION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes 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-installed products.
6. Progress cleaning.
7. Starting and adjusting.
8. Protection of installed construction.

B. Related Requirements:

1. Section 011000 "Summary" for limits on use of Project site.
2. Section 013300 "Submittal Procedures" for submitting surveys.
3. 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.
4. Section 024119 "Selective Demolition" for demolition and removal of selected portions of the building.

1.3 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.

1.4 PREINSTALLATION MEETINGS

A. Cutting and Patching Conference: Conduct conference at Project site.

1. Prior to submitting cutting and patching plan, review extent of cutting and patching anticipated and examine procedures for ensuring satisfactory result from cutting and patching work. Require representatives of each entity directly concerned with cutting and patching to attend, including the following:

a. Contractor's superintendent.
b. Trade supervisor responsible for cutting operations.
c. Trade supervisor(s) responsible for patching of each type of substrate.
d. Mechanical, electrical, and utilities subcontractors' supervisors, to the extent each trade is affecting by cutting and patching operations.

2. Review areas of potential interference and conflict. Coordinate procedures and resolve potential conflicts before proceeding.

1.5 INFORMATIONAL SUBMITTALS

A. Cutting and Patching Plan: Submit plan describing procedures at least 10 days prior to the time cutting and patching will be performed. Include the following information:

1. Extent: Describe reason for and extent of each occurrence of cutting and patching.
2. Changes to In-Place Construction: Describe anticipated results. Include changes to structural elements and operating components as well as changes in building appearance and other significant visual elements.
3. Products: List products to be used for patching and firms or entities that will perform patching work.
4. Dates: Indicate when cutting and patching will be performed.
5. Utilities and Mechanical and Electrical Systems: List services and systems that cutting and patching procedures will disturb or affect. List services and systems that will be relocated and those that will be temporarily out of service. Indicate length of time permanent services and systems will be disrupted.

a. Include description of provisions for temporary services and systems during interruption of permanent services and systems.

B. Landfill Receipts: Submit copy of receipts issued by a landfill facility, licensed to accept hazardous materials, for hazardous waste disposal.

1.6 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, notify Architect of locations and details of cutting and await directions from Architect 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. Operational elements include the following:

a. Primary operational systems and equipment.
b. Fire separation assemblies.
c. Air or smoke barriers.
d. Fire-suppression systems.
e. Plumbing piping systems.

f. Mechanical systems piping and ducts.
g. Control systems.
h. Communication systems.
i. Fire-detection and -alarm systems.
j. Conveying systems.
k. Electrical wiring systems.
l. Operating systems of special construction.

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. Other construction elements include but are not limited to the following:

a. Water, moisture, or vapor barriers.
b. Membranes and flashings.
c. Exterior curtain-wall construction.
d. Sprayed fire-resistive material.
e. Equipment supports.
f. Piping, ductwork, vessels, and equipment.
g. Noise- and vibration-control elements and systems.

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 Architect'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 products and equipment.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General: 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 Architect for the visual and functional performance of in-place materials.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Existing Conditions: The existence and location of underground and other utilities and construction indicated as existing are not guaranteed. Before beginning sitework, investigate and verify the existence and location of underground utilities, mechanical and electrical systems, and other construction affecting the Work.

1. Before construction, verify the location and invert elevation at points of connection of sanitary sewer, storm sewer, and water-service piping; underground electrical services; and other utilities.
2. Furnish location data for work related to Project that must be performed by public utilities serving Project site.

B. 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.

C. 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.
2. List of detrimental conditions, including substrates.
3. List of unacceptable installation tolerances.
4. Recommended corrections.

D. 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 local utility 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 caused by differing field conditions outside the control of Contractor, submit a request for information to Architect according to requirements in Section 013100 "Project Management and Coordination."

3.3 CONSTRUCTION LAYOUT

A. Verification: Before proceeding to lay out the Work, verify layout information shown on Drawings, in relation to the property survey and existing benchmarks. If discrepancies are discovered, notify Architect promptly.

3.4 FIELD ENGINEERING

A. Identification: Owner will identify existing benchmarks, control points, and property corners.

B. Reference Points: Locate existing permanent benchmarks, control points, and similar reference points before beginning the Work. Preserve and protect permanent benchmarks and control points during construction operations.

1. Do not change or relocate existing benchmarks or control points without prior written approval of Architect[or Construction Manager]. Report lost or destroyed permanent benchmarks or control points promptly. Report the need to relocate permanent benchmarks or control points to Architect[and Construction Manager] before proceeding.
2. Replace lost or destroyed permanent benchmarks and control points promptly. Base replacements on the original survey control points.

3.5 INSTALLATION

A. General: 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.

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 the best possible results. 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.

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: Where possible, 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.

1. Mounting Heights: Where mounting heights are not indicated, mount components at heights directed by Architect.
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. 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.

3.6 CUTTING AND PATCHING

A. Cutting and Patching, 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 according to 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 prevent 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. 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 minimize 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. 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.

3.7 OWNER-INSTALLED PRODUCTS

A. Site Access: Provide access to Project site for Owner's construction personnel.

B. Coordination: Coordinate construction and operations of the Work with work performed by Owner's construction personnel.

1. Construction Schedule: Inform Owner of Contractor's preferred construction schedule for Owner's portion of the Work. Adjust construction schedule based on a mutually agreeable timetable. Notify Owner if changes to schedule are required due to differences in actual construction progress.
2. Preinstallation Conferences: Include Owner's construction personnel at preinstallation conferences covering portions of the Work that are to receive Owner's work. Attend preinstallation conferences conducted by Owner's construction personnel if portions of the Work depend on Owner's construction.

3.8 PROGRESS CLEANING

A. General: 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 in Finished Areas: 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.

3.9 STARTING AND ADJUSTING

A. Coordinate startup and adjusting of equipment and operating components with requirements in Section 019113 "General 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."

3.10 PROTECTION 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. 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.

C. 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 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1. Salvaging nonhazardous demolition construction waste.
2. Recycling nonhazardous demolition construction waste.
3. Disposing of nonhazardous demolition construction waste.

1.3 DEFINITIONS

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

B. Demolition Waste: Building, structure, and site improvement materials resulting from demolition operations.

C. Disposal: Removal of demolition or construction waste and subsequent salvage, sale, recycling, or deposit in landfill, incinerator acceptable to authorities having jurisdiction, or designated spoil areas on Owner’s property.

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.

1.4 MATERIALS OWNERSHIP

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

1.5 ACTION SUBMITTALS

A. Waste Management Plan: Submit plan within 7 days of date established for the Notice to Proceed.

1.6 INFORMATIONAL SUBMITTALS

A. Recycling and Processing Facility Records: Indicate receipt and acceptance of recyclable waste by recycling and processing facilities licensed to accept them. Include manifests, weight tickets, receipts, and invoices.

B. 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.

C. Statement of Refrigerant Recovery: Signed by refrigerant recovery technician responsible for recovering refrigerant, stating that all refrigerant that was present was recovered and that recovery was performed according to EPA regulations. Include name and address of technician and date refrigerant was recovered.

D. Refrigerant Recovery: Comply with requirements in Section 024119 "Selective Demolition" for refrigerant recovery submittals.

1.7 QUALITY ASSURANCE

A. Refrigerant Recovery Technician Qualifications: Universal certified by EPA-approved certification program.

B. Refrigerant Recovery Technician Qualifications: Comply with requirements in Section 024119 "Selective Demolition."

C. Regulatory Requirements: Comply with transportation and disposal regulations of authorities having jurisdiction.

1.8 WASTE MANAGEMENT PLAN

A. General: Develop a waste management plan according to requirements in this Section. Plan shall consist of waste identification, waste reduction work plan, and cost/revenue analysis. Distinguish between demolition and construction waste. Indicate quantities by weight or volume, but use same units of measure throughout waste management plan. CWM forms, included in this section, to be completed monthly.

B. Waste Identification: Indicate anticipated types and quantities of demolition and construction waste generated by the Work. Use Form CWM-1 for construction waste and Form CWM-2 for demolition waste. Include estimated quantities and assumptions for estimates.

C. Waste Reduction Work Plan: List each type of waste and whether it will be salvaged, recycled, or disposed of in landfill or incinerator. Use Form CWM-3 for construction waste and Form CWM-4 for demolition waste. 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 in compliance with Section 024119 "Selective Demolition."

2. Recycled Materials: Include list of local receivers and processors and type of recycled materials each will accept. Include names, addresses, and telephone numbers.
3. Disposed Materials: Indicate how and where materials will be disposed of. Include name, address, and telephone number of each landfill and incinerator facility.
4. 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

2.1 PERFORMANCE REQUIREMENTS

A. General: Achieve end-of-Project rates for salvage/recycling of 50 percent by weight of total nonhazardous solid waste generated by the Work. Practice efficient waste management in the use of materials in the course of the Work. Use all reasonable means to divert construction and demolition waste from landfills and incinerators. Facilitate recycling and salvage of materials, including the following:

1. Demolition Waste:

    a. Wood joists.
    b. Plywood and oriented strand board.
    c. Structural and miscellaneous steel.
    d. Roofing.
    e. Insulation.
    f. Metal studs.
    g. Gypsum board.
    h. Equipment.
    i. Piping.
    j. Supports and hangers.
    k. Valves.
    l. Mechanical equipment.
    m. Refrigerants.
    n. Electrical conduit.
    o. Copper wiring.
    p. Electrical devices.
    q. Switchgear and panelboards.
    r. Transformers.

2. Construction Waste:

    a. Lumber.
    b. Wood sheet materials.
    c. Metals.
    d. Roofing.
    e. Insulation.
    f. Gypsum board.
    g. Piping.
    h. Electrical conduit.

i. Packaging: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following uncontaminated packaging materials:

1) Paper.
2) Cardboard.
3) Boxes.
4) Plastic sheet and film.
5) Polystyrene packaging.
6) Wood crates.
7) Wood pallets.
8) Plastic pails.

j. Construction Office Waste: Regardless of salvage/recycle goal indicated in "General" Paragraph above, salvage or recycle 100 percent of the following construction office waste materials:

1) Paper.
2) Aluminum cans.
3) Glass containers.

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.

1. Comply with operation, termination, and removal requirements in Section 015000 "Temporary Facilities and Controls."

B. Training: Train workers, subcontractors, and suppliers on proper waste management procedures, as appropriate for the Work.

1. Distribute waste management plan to everyone concerned within three days of submittal return.
2. Distribute waste management plan to entities when they first begin work on-site. Review plan procedures and locations established for salvage, recycling, and disposal.

C. 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 and recycled.
2. Comply with Section 015000 "Temporary Facilities and Controls" for controlling dust and dirt, environmental protection, and noise control.

3.2 SALVAGING DEMOLITION WASTE

A. Comply with requirements in Section 024119 "Selective Demolition" for salvaging demolition waste.

B. Salvaged Items for Reuse in the Work: Salvage items for reuse and handle as follows:

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 installation.
4. Protect items from damage during transport and storage.
5. Install salvaged items to comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make items functional for use indicated.

C. Equipment: Drain tanks, piping, and fixtures. Seal openings with caps or plugs. Protect equipment from exposure to weather.

D. Electrical Devices: Separate switches, receptacles, switchgear, transformers, meters, panelboards, circuit breakers, and other devices by type.

3.3 RECYCLING DEMOLITION CONSTRUCTION WASTE, GENERAL

A. General: Recycle paper and beverage containers used by on-site workers.

B. Recycling Incentives: Revenues, savings, rebates, tax credits, and other incentives received for recycling waste materials shall be shared equally by Owner and Contractor.

C. Preparation of Waste: Prepare and maintain recyclable waste materials according to recycling or reuse facility requirements. Maintain materials free of dirt, adhesives, solvents, petroleum contamination, and other substances deleterious to the recycling process.

D. Procedures: Separate recyclable waste from other waste materials, trash, and debris. Separate recyclable waste by type at Project site to the maximum extent practical according to approved construction waste management plan.

1. Provide appropriately marked containers or bins for controlling recyclable waste until removed from Project site. Include list of acceptable and unacceptable materials at each container and bin.

    a. Inspect containers and bins for contamination and remove contaminated materials if found.

2. Stockpile processed materials on-site without intermixing with other materials. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
3. Stockpile materials away from construction area. Do not store within drip line of remaining trees.
4. Store components off the ground and protect from the weather.
5. Remove recyclable waste from Owner's property and transport to recycling receiver or processor as often as required to prevent overfilling bins.

3.4 RECYCLING DEMOLITION WASTE

A. Wood Materials: Sort and stack members according to size, type, and length. Separate lumber, engineered wood products, panel products, and treated wood materials.

B. Metals: Separate metals by type.

1. Structural Steel: Stack members according to size, type of member, and length.
2. Remove and dispose of bolts, nuts, washers, and other rough hardware.

C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location. Remove edge trim and sort with other metals. Remove and dispose of fasteners.

D. Piping: Reduce piping to straight lengths and store by material and size. Separate supports, hangers, valves, sprinklers, and other components by material and size.

E. Conduit: Reduce conduit to straight lengths and store by material and size.

3.5 RECYCLING CONSTRUCTION WASTE

A. Packaging:

1. Cardboard and Boxes: Break down packaging into flat sheets. Bundle and store in a dry location.
2. Polystyrene Packaging: Separate and bag materials.
3. Pallets: As much as possible, require deliveries using pallets to remove pallets from Project site. For pallets that remain on-site, break down pallets into component wood pieces and comply with requirements for recycling wood.
4. Crates: Break down crates into component wood pieces and comply with requirements for recycling wood.

B. Wood Materials:

1. Clean Cut-Offs of Lumber: Grind or chip into small pieces.
2. Clean Sawdust: Bag sawdust that does not contain painted or treated wood.

a. Comply with requirements in Section 329300 "Plants" for use of clean sawdust as organic mulch.

C. Gypsum Board: Stack large clean pieces on wood pallets or in container and store in a dry location.

1. Clean Gypsum Board: Grind scraps of clean gypsum board using small mobile chipper or hammer mill. Screen out paper after grinding.

a. Comply with requirements in Section 329300 "Plants" for use of clean ground gypsum board as inorganic soil amendment.

D. Paint: Seal containers and store by type.

3.6 DISPOSAL OF WASTE

A. General: Except for items or materials to be salvaged or recycled, 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. General: Except for items or materials to be salvaged or recycled, remove waste materials and legally dispose of at designated spoil areas on Owner'¢s property.

C. Burning: Do not burn waste materials.

3.7 ATTACHMENTS

A. Form CWM-1 for construction waste identification.

B. Form CWM-2 for demolition waste identification.

C. Form CWM-3 for construction waste reduction work plan.

D. Form CWM-4 for demolition waste reduction work plan.

E. Form CWM-5 for cost/revenue analysis of construction waste reduction work plan.

F. Form CWM-6 for cost/revenue analysis of demolition waste reduction work plan.

G. Form CWM-7 for construction waste reduction progress report.

H. Form CWM-8 for demolition waste reduction progress report.

END OF SECTION 017419

FORM CWM-1: CONSTRUCTION WASTE IDENTIFICATION							
MATERIAL CATEGORY	GENERATION POINT	EST. QUANTITY OF MATERIALS RECEIVED* (A)	EST. WASTE - % (B)	TOTAL EST. QUANTITY OF WASTE* (C = A X B)	EST. VOLUME CY (CM)	EST. WEIGHT TONS (TONNES)	REMARKS AND ASSUMPTIONS
Packaging: Cardboard							
Packaging: Boxes							
Packaging: Plastic Sheet or Film							
Packaging: Polystyrene							
Packaging: Pallets or Skids							
Packaging: Crates							
Packaging: Paint Cans							
Packaging: Plastic Pails							
Site-Clearing Waste							
Masonry or CMU							
Lumber: Cut-Offs							
Lumber: Warped Pieces							
Plywood or OSB (scraps)							
Wood Forms							
Wood Waste Chutes							
Wood Trim (cut-offs)							
Metals							
Insulation							
Roofing							
Joint Sealant Tubes							
Gypsum Board (scraps)							
Carpet and Pad (scraps)							
Piping							
Electrical Conduit							
Other:							

* Insert units of measure.

FORM CWM-2: DEMOLITION WASTE IDENTIFICATION				
MATERIAL DESCRIPTION	EST. QUANTITY	EST. VOLUME CY (CM)	EST. WEIGHT TONS (TONNES)	REMARKS AND ASSUMPTIONS
Asphaltic Concrete Paving				
Concrete				
Brick				
CMU				
Lumber				
Plywood and OSB				
Wood Paneling				
Wood Trim				
Miscellaneous Metals				
Structural Steel				
Rough Hardware				
Insulation				
Roofing				
Doors and Frames				
Door Hardware				
Windows				
Glazing				
Acoustical Tile				
Carpet				
Carpet Pad				
Demountable Partitions				
Equipment				
Cabinets				
Plumbing Fixtures				
Piping				
Piping Supports and Hangers				
Valves				
Sprinklers				
Mechanical Equipment				
Electrical Conduit				
Copper Wiring				
Light Fixtures				
Lamps				
Lighting Ballasts				
Electrical Devices				
Switchgear and Panelboards				
Transformers				
Other:				

FORM CWM-3: CONSTRUCTION WASTE REDUCTION WORK PLAN						
MATERIAL CATEGORY	GENERATION POINT	TOTAL EST. QUANTITY OF WASTE TONS (TONNES)	DISPOSAL METHOD AND QUANTITY			HANDLING AND TRANSPORTION PROCEDURES
			EST. AMOUNT SALVAGED TONS (TONNES)	EST. AMOUNT RECYCLED TONS (TONNES)	EST. AMOUNT DISPOSED TO LANDFILL TONS (TONNES)	
Packaging: Cardboard						
Packaging: Boxes						
Packaging: Plastic Sheet or Film						
Packaging: Polystyrene						
Packaging: Pallets or Skids						
Packaging: Crates						
Packaging: Paint Cans						
Packaging: Plastic Pails						
Site-Clearing Waste						
Masonry or CMU						
Lumber: Cut-Offs						
Lumber: Warped Pieces						
Plywood or OSB (scraps)						
Wood Forms						
Wood Waste Chutes						
Wood Trim (cut-offs)						
Metals						
Insulation						
Roofing						
Joint Sealant Tubes						
Gypsum Board (scraps)						
Carpet and Pad (scraps)						
Piping						
Electrical Conduit						
Other:						

FORM CWM-4: DEMOLITION WASTE REDUCTION WORK PLAN						
MATERIAL CATEGORY	GENERATION POINT	TOTAL EST. QUANTITY OF WASTE TONS (TONNES)	DISPOSAL METHOD AND QUANTITY			HANDLING AND TRANSPORTION PROCEDURES
			EST. AMOUNT SALVAGED TONS (TONNES)	EST. AMOUNT RECYCLED TONS (TONNES)	EST. AMOUNT DISPOSED TO LANDFILL TONS (TONNES)	
Asphaltic Concrete Paving						
Concrete						
Brick						
CMU						
Lumber						
Plywood and OSB						
Wood Paneling						
Wood Trim						
Miscellaneous Metals						
Structural Steel						
Rough Hardware						
Insulation						
Roofing						
Doors and Frames						
Door Hardware						
Windows						
Glazing						
Acoustical Tile						
Carpet						
Carpet Pad						
Demountable Partitions						
Equipment						
Cabinets						
Plumbing Fixtures						
Piping						
Supports and Hangers						
Valves						
Sprinklers						
Mechanical Equipment						
Electrical Conduit						
Copper Wiring						
Light Fixtures						
Lamps						
Lighting Ballasts						
Electrical Devices						
Switchgear and Panelboards						
Transformers						
Other:						

FORM CWM-5: COST/REVENUE ANALYSIS OF CONSTRUCTION WASTE REDUCTION WORK PLAN								
MATERIALS	TOTAL QUANTITY OF MATERIALS (VOL. OR WEIGHT) (A)	EST. COST OF DISPOSAL (B)	TOTAL EST. COST OF DISPOSAL (C = A x B)	REVENUE FROM SALVAGED MATERIALS (D)	REVENUE FROM RECYCLED MATERIALS (E)	LANDFILL TIPPING FEES AVOIDED (F)	HANDLING AND TRANSPORTATION COSTS AVOIDED (G)	NET COST SAVINGS OF WORK PLAN (H = D+E+F+G)
Packaging: Cardboard								
Packaging: Boxes								
Packaging: Plastic Sheet or Film								
Packaging: Polystyrene								
Packaging: Pallets or Skids								
Packaging: Crates								
Packaging: Paint Cans								
Packaging: Plastic Pails								
Site-Clearing Waste								
Masonry or CMU								
Lumber: Cut-Offs								
Lumber: Warped Pieces								
Plywood or OSB (scraps)								
Wood Forms								
Wood Waste Chutes								
Wood Trim (cut-offs)								
Metals								
Insulation								
Roofing								
Joint Sealant Tubes								
Gypsum Board (scraps)								
Carpet and Pad (scraps)								
Piping								
Electrical Conduit								
Other:								

FORM CWM-6: COST/REVENUE ANALYSIS OF DEMOLITION WASTE REDUCTION WORK PLAN								
MATERIALS	TOTAL QUANTITY OF MATERIALS (VOL. OR WEIGHT) (A)	EST. COST OF DISPOSAL (B)	TOTAL EST. COST OF DISPOSAL (C = A x B)	REVENUE FROM SALVAGED MATERIALS (D)	REVENUE FROM RECYCLED MATERIALS (E)	LANDFILL TIPPING FEES AVOIDED (F)	HANDLING AND TRANSPORTATION COSTS AVOIDED (G)	NET COST SAVINGS OF WORK PLAN (H = D+E+F+G)
Asphaltic Concrete Paving								
Concrete								
Brick								
CMU								
Lumber								
Plywood and OSB								
Wood Paneling								
Wood Trim								
Miscellaneous Metals								
Structural Steel								
Rough Hardware								
Insulation								
Roofing								
Doors and Frames								
Door Hardware								
Windows								
Glazing								
Acoustical Tile								
Carpet								
Carpet Pad								
Demountable Partitions								
Equipment								
Cabinets								
Plumbing Fixtures								
Piping								
Supports and Hangers								
Valves								
Sprinklers								
Mech. Equipment								
Electrical Conduit								
Copper Wiring								
Light Fixtures								
Lamps								
Lighting Ballasts								
Electrical Devices								
Switchgear and Panelboards								
Transformers								
Other:								

FORM CWM-7: CONSTRUCTION WASTE REDUCTION PROGRESS REPORT								
MATERIAL CATEGORY	GENERATION POINT	TOTAL QUANTITY OF WASTE TONS (TONNES) (A)	QUANTITY OF WASTE SALVAGED		QUANTITY OF WASTE RECYCLED		TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)	TOTAL QUANTITY OF WASTE RECOVERED % (D / A x 100)
			ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (B)	ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (C)		
Packaging: Cardboard								
Packaging: Boxes								
Packaging: Plastic Sheet or Film								
Packaging: Polystyrene								
Packaging: Pallets or Skids								
Packaging: Crates								
Packaging: Paint Cans								
Packaging: Plastic Pails								
Site-Clearing Waste								
Masonry or CMU								
Lumber: Cut-Offs								
Lumber: Warped Pieces								
Plywood or OSB (scraps)								
Wood Forms								
Wood Waste Chutes								
Wood Trim (cut-offs)								
Metals								
Insulation								
Roofing								
Joint Sealant Tubes								
Gypsum Board (scraps)								
Carpet and Pad (scraps)								
Piping								
Electrical Conduit								
Other:								

FORM CWM-8: DEMOLITION WASTE REDUCTION PROGRESS REPORT								
MATERIAL CATEGORY	GENERATION POINT	TOTAL QUANTITY OF WASTE TONS (TONNES) (A)	QUANTITY OF WASTE SALVAGED		QUANTITY OF WASTE RECYCLED		TOTAL QUANTITY OF WASTE RECOVERED TONS (TONNES) (D = B + C)	TOTAL QUANTITY OF WASTE RECOVERED % (D / A x 100)
			ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (B)	ESTIMATED TONS (TONNES)	ACTUAL TONS (TONNES) (C)		
Asphaltic Concrete Paving								
Concrete								
Brick								
CMU								
Lumber								
Plywood and OSB								
Wood Paneling								
Wood Trim								
Miscellaneous Metals								
Structural Steel								
Rough Hardware								
Insulation								
Roofing								
Doors and Frames								
Door Hardware								
Windows								
Glazing								
Acoustical Tile								
Carpet								
Carpet Pad								
Demountable Partitions								
Equipment								
Cabinets								
Plumbing Fixtures								
Piping								
Supports and Hangers								
Valves								
Sprinklers								
Mechanical Equipment								
Electrical Conduit								
Copper Wiring								
Light Fixtures								
Lamps								
Lighting Ballasts								
Electrical Devices								
Switchgear and Panelboards								
Transformers								
Other:								

SECTION 017700 - CLOSEOUT PROCEDURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for contract closeout, including, but not limited to, the following:

1. Substantial Completion procedures.
2. Final completion procedures.
3. Warranties.
4. Final cleaning.
5. Repair of the Work.

B. Related Requirements:

1. Section 013233 "Photographic Documentation" for submitting final completion construction photographic documentation.
2. Section 017823 "Operation and Maintenance Data" for additional operation and maintenance manual requirements.
3. Section 017839 "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
4. Section 017900 "Demonstration and Training" for requirements to train the Owner's maintenance personnel to adjust, operate, and maintain products, equipment, and systems.

1.3 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.

1.4 CLOSEOUT SUBMITTALS

A. Certificates of Release: From authorities having jurisdiction.

B. Certificate of Insurance: For continuing coverage.

C. Field Report: For pest control inspection.

1.5 MAINTENANCE MATERIAL SUBMITTALS

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

1.6 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 Architect. Label with manufacturer's name and model number.

    a. Schedule of Maintenance Material Items: Prepare and submit schedule of maintenance material submittal items, including name and quantity of each item and name and number of related Specification Section. Obtain Owner's signature for receipt of submittals.

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

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

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

B. Inspection: Submit a written request for final inspection to determine acceptance a minimum of 10 days prior to date the work will be completed and ready for final inspection and tests. On receipt of request, Architect will either proceed with inspection or notify Contractor of unfulfilled requirements. Architect will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

1. Request reinspection when the Work identified in previous inspections as incomplete is completed or corrected.

1.8 LIST OF INCOMPLETE ITEMS (PUNCH LIST)

A. Organization of List: Include name and identification of each space and area affected by construction operations for incomplete items and items needing correction including, if necessary, areas disturbed by Contractor that are outside the limits of construction.

1. Organize list of spaces in sequential order, starting with exterior areas firstand proceeding from lowest floor to highest floor.
2. Organize items applying to each space by major element, including categories for ceiling, individual walls, floors, equipment, and building systems.
3. Include the following information at the top of each page:

    a. Project name.
    b. Date.
    c. Name of Architect.
    d. Name of Contractor.
    e. Page number.

4. Submit list of incomplete items in the following format:

    a. Web-based project software upload. Utilize software feature for creating and updating list of incomplete items (punch list).

1.9 SUBMITTAL OF PROJECT WARRANTIES

A. Time of Submittal: Submit written warranties on request of Architect 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 by uploading to web-based project software site.

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.
    2. Provide heavy paper dividers with plastic-covered tabs for each separate warranty. Mark tab to identify the product or installation. Provide a typed description of the product or installation, including the name of the product and the name, address, and telephone number of Installer.
    3. Identify each binder on the front and spine with the typed or printed title "WARRANTIES," Project name, and name of Contractor.

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.

1. Use cleaning products that comply with Green Seal's GS-37, or if GS-37 is not applicable, use products that comply with the California Code of Regulations maximum allowable VOC levels.

PART 3 - EXECUTION

3.1 FINAL CLEANING

A. General: Perform final cleaning. Conduct cleaning and waste-removal operations to comply with local laws and ordinances and Federal and local environmental and antipollution regulations.

B. Cleaning: Employ experienced workers or professional cleaners for final cleaning. Clean each surface or unit to condition expected in an average commercial building cleaning and maintenance program. Comply with manufacturer's written instructions.

1. Complete the following cleaning operations before requesting inspection for certification of Substantial Completion for entire Project or for a designated portion of Project:

a. Clean Project site, yard, and grounds, in areas disturbed by construction activities, including landscape development areas, of rubbish, waste material, litter, and other foreign substances.
b. Sweep paved areas broom clean. Remove petrochemical spills, stains, and other foreign deposits.
c. Rake grounds that are not planted, mulched, or paved to a smooth, even-textured surface.
d. Remove tools, construction equipment, machinery, and surplus material from Project site.
e. Remove snow and ice to provide safe access to building.
f. Clean exposed exterior and interior hard-surfaced finishes to a dirt-free condition, free of stains, films, and similar foreign substances. Avoid disturbing natural weathering of exterior surfaces. Restore reflective surfaces to their original condition.
g. Remove debris and surface dust from limited access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
h. Sweep concrete floors broom clean in unoccupied spaces.
i. Vacuum carpet and similar soft surfaces, removing debris and excess nap; clean according to manufacturer's recommendations if visible soil or stains remain.

j. Clean transparent materials, including mirrors and glass in doors and windows. Remove glazing compounds and other noticeable, vision-obscuring materials. Polish mirrors and glass, taking care not to scratch surfaces.
k. Remove labels that are not permanent.
l. Wipe surfaces of mechanical and electrical equipment and similar equipment. Remove excess lubrication, paint and mortar droppings, and other foreign substances.
m. Clean plumbing fixtures to a sanitary condition, free of stains, including stains resulting from water exposure.
n. Replace disposable air filters and clean permanent air filters. Clean exposed surfaces of diffusers, registers, and grills.
o. Clean ducts, blowers, and coils if units were operated without filters during construction or that display contamination with particulate matter on inspection.

1) Clean HVAC system in compliance with NADCA ACR. Provide written report on completion of cleaning.

p. Clean luminaires, lamps, globes, and reflectors to function with full efficiency.
q. Leave Project clean and ready for occupancy.

C. Pest Control: Comply with pest control requirements in Section 015000 "Temporary Facilities and Controls." Prepare written report.

D. 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 before requesting inspection for determination of Substantial Completion.

B. Repair, or remove and replace, defective construction. Repairing includes replacing defective parts, refinishing damaged surfaces, touching up with matching materials, and properly adjusting operating equipment. Where damaged or worn items cannot be repaired or restored, provide replacements. Remove and replace operating components that cannot be repaired. Restore damaged construction and permanent facilities used during construction to specified condition.

1. Remove and replace chipped, scratched, and broken glass, reflective surfaces, and other damaged transparent materials.
2. Touch up and otherwise repair and restore marred or exposed finishes and surfaces. Replace finishes and surfaces that that already show evidence of repair or restoration.

a. Do not paint over "UL" and other required labels and identification, including mechanical and electrical nameplates. Remove paint applied to required labels and identification.

3. Replace parts subject to operating conditions during construction that may impede operation or reduce longevity.

4. Replace burned-out bulbs, bulbs noticeably dimmed by hours of use, and defective and noisy starters in fluorescent and mercury vapor fixtures to comply with requirements for new fixtures.

END OF SECTION 017700

SECTION 017823 - OPERATION AND MAINTENANCE DATA

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. 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.

B. Related Requirements:

1. Section 013300 "Submittal Procedures" for submitting copies of submittals for operation and maintenance manuals.
2. Section 019113 "General Commissioning Requirements" for verification and compilation of data into operation and maintenance manuals.

1.3 DEFINITIONS

A. System: An organized collection of parts, equipment, or subsystems united by regular interaction.

B. Subsystem: A portion of a system with characteristics similar to a system.

1.4 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. Architect 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 by uploading to web-based project software site. Enable reviewer comments on draft submittals.
2. Submit three paper copies. Architect will return two copies.

C. Initial Manual Submittal: Submit draft copy of each manual at least 30 days before commencing demonstration and training. Architect and Commissioning Authority will comment on whether general scope and content of manual are acceptable.

D. 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. Architect and Commissioning Authority will return copy with comments.

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

E. Comply with Section 017700 "Closeout Procedures" for schedule for submitting operation and maintenance documentation.

1.5 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.

B. Manuals, Paper Copy: Submit manuals in the form of hard-copy, bound and labeled volumes.

1. Binders: Heavy-duty, three-ring, vinyl-covered, post-type binders, in thickness necessary to accommodate contents, sized to hold 8-1/2-by-11-inch paper; with clear plastic sleeve on spine to hold label describing contents and with pockets inside covers to hold folded oversize sheets.

a. If two or more binders are necessary to accommodate data of a system, organize data in each binder into groupings by subsystem and related components. Cross-reference other binders if necessary to provide essential information for proper operation or maintenance of equipment or system.
b. Identify each binder on front and spine, with printed title "OPERATION AND MAINTENANCE MANUAL," Project title or name, and subject matter of contents, and indicate Specification Section number on bottom of spine. Indicate volume number for multiple-volume sets.

2. Dividers: Heavy-paper dividers with plastic-covered tabs for each section of the manual. Mark each tab to indicate contents. Include typed list of products and major components of equipment included in the section on each divider, cross-referenced to Specification Section number and title of Project Manual.
3. Protective Plastic Sleeves: Transparent plastic sleeves designed to enclose diagnostic software storage media for computerized electronic equipment. Enclose title pages and directories in clear plastic sleeves.
4. Supplementary Text: Prepared on 8-1/2-by-11-inch white bond paper.
5. Drawings: Attach reinforced, punched binder tabs on drawings and bind with text.

    a. If oversize drawings are necessary, fold drawings to same size as text pages and use as foldouts.
    b. If drawings are too large to be used as foldouts, fold and place drawings in labeled envelopes and bind envelopes in rear of manual. At appropriate locations in manual, insert typewritten pages indicating drawing titles, descriptions of contents, and drawing locations.

1.6 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 Construction Manager.
7. Name and contact information for Architect.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Architect that designed the systems contained in the manuals.
10. Cross-reference to related systems in other operation and maintenance manuals.

C. Table of Contents: List each product included in manual, identified by product name, indexed to the content of the volume, and cross-referenced to Specification Section number in Project Manual.

1. If operation or maintenance documentation requires more than one volume to accommodate data, include comprehensive table of contents for all volumes in each volume of the set.

D. Manual Contents: Organize into sets of manageable size. Arrange contents alphabetically by system, subsystem, and equipment. If possible, assemble instructions for subsystems, equipment, and components of one system into a single binder.

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."

1.7 OPERATION AND MAINTENANCE DOCUMENTATION DIRECTORY MANUAL

A. Operation and Maintenance Documentation Directory: Prepare a separate manual that provides an organized reference to emergency, operation, and maintenance manuals. List items and their location to facilitate ready access to desired information. Include the following:

1. List of Systems and Subsystems: List systems alphabetically. Include references to operation and maintenance manuals that contain information about each system.
2. List of Equipment: List equipment for each system, organized alphabetically by system. For pieces of equipment not part of system, list alphabetically in separate list.
3. Tables of Contents: Include a table of contents for each emergency, operation, and maintenance manual.

1.8 EMERGENCY MANUALS

A. Emergency Manual: Assemble a complete set of emergency information indicating procedures for use by emergency personnel and by Owner's operating personnel for types of emergencies indicated.

B. Content: Organize manual into a separate section for each of the following:

1. Type of emergency.
2. Emergency instructions.
3. Emergency procedures.

C. Type of Emergency: Where applicable for each type of emergency indicated below, include instructions and procedures for each system, subsystem, piece of equipment, and component:

1. Fire.
2. Flood.
3. Gas leak.
4. Water leak.
5. Power failure.
6. Water outage.
7. System, subsystem, or equipment failure.
8. Chemical release or spill.

D. 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.

E. 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.

1.9 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.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

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

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

1.10 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.

1. Engage a factory-authorized service representative to assemble and prepare information for each system, subsystem, and piece of equipment not part of a system.
2. Prepare a separate manual for each system and subsystem, in the form of an instructional manual for use by Owner's operating personnel.

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. Source Information: List each system, subsystem, and piece of equipment included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

D. 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.

E. 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.

F. Maintenance and Service Schedules: Include service and lubrication requirements, list of required lubricants for equipment, and separate schedules for preventive and routine maintenance and service with standard time allotment.

1. Scheduled Maintenance and Service: Tabulate actions for daily, weekly, monthly, quarterly, semiannual, and annual frequencies.
2. Maintenance and Service Record: Include manufacturers' forms for recording maintenance.

G. 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.

H. Maintenance Service Contracts: Include copies of maintenance agreements with name and telephone number of service agent.

I. 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.

J. Drawings: Prepare drawings supplementing manufacturers' printed data to illustrate the relationship of component parts of equipment and systems and to illustrate control sequence and flow diagrams. Coordinate these drawings with information contained in record Drawings to ensure correct illustration of completed installation.

1. Do not use original project record documents as part of maintenance manuals.

1.11 PRODUCT MAINTENANCE MANUALS

A. Product Maintenance Manual: Assemble a complete set of maintenance data indicating care and maintenance of each product, material, and finish incorporated into the Work.

B. Content: Organize manual into a separate section for each product, material, and finish. Include source information, product information, maintenance procedures, repair materials and sources, and warranties and bonds, as described below.

C. Source Information: List each product included in manual, identified by product name and arranged to match manual's table of contents. For each product, list name, address, and telephone number of Installer or supplier and maintenance service agent, and cross-reference Specification Section number and title in Project Manual and drawing or schedule designation or identifier where applicable.

D. Product Information: Include the following, as applicable:

1. Product name and model number.
2. Manufacturer's name.
3. Color, pattern, and texture.
4. Material and chemical composition.
5. Reordering information for specially manufactured products.

E. Maintenance Procedures: Include manufacturer's written recommendations and the following:

1. Inspection procedures.
2. Types of cleaning agents to be used and methods of cleaning.
3. List of cleaning agents and methods of cleaning detrimental to product.
4. Schedule for routine cleaning and maintenance.
5. Repair instructions.

F. Repair Materials and Sources: Include lists of materials and local sources of 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 017823

SECTION 017839 - PROJECT RECORD DOCUMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for project record documents, including the following:

1. Record Drawings.
2. Record Specifications.
3. Record Product Data.
4. Miscellaneous record submittals.

B. Related Requirements:

1. Section 017300 "Execution" for final property survey.
2. Section 017700 "Closeout Procedures" for general closeout procedures.
3. Section 017823 "Operation and Maintenance Data" for operation and maintenance manual requirements.

1.3 CLOSEOUT SUBMITTALS

A. Record Drawings: Comply with the following:

1. Number of Copies: Submit copies of record Drawings as follows:

a. Initial Submittal:

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

b. Final Submittal:

1) Submit PDF electronic files of scanned record prints and three set(s) of prints.
2) Print each drawing, whether or not changes and additional information were recorded.

B. Record Specifications: Submit annotated PDF electronic files of Project's Specifications, including addenda and contract modifications.

C. 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.

D. Miscellaneous Record Submittals: See other Specification Sections for miscellaneous record-keeping requirements and submittals in connection with various construction activities. Submit annotated PDF electronic files and directories of each submittal.

E. Reports: Submit written report weekly indicating items incorporated into project record documents concurrent with progress of the Work, including revisions, concealed conditions, field changes, product selections, and other notations incorporated.

1.4 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 Architect'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 important additional information that was either shown schematically or omitted from original Drawings.
5. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.

B. Record Digital Data Files: Immediately before inspection for Certificate of Substantial Completion, review marked-up record prints with Architect. When authorized, prepare a full set of corrected digital data files of the Contract Drawings, as follows:

1. Format: Same digital data software program, version, and operating system as the original Contract Drawings.
2. Format: DWG, Version Current, Microsoft Windows operating system.
3. Format: Annotated PDF electronic file with comment function enabled.
4. Incorporate changes and additional information previously marked on record prints. Delete, redraw, and add details and notations where applicable.
5. Refer instances of uncertainty to Architect for resolution.
6. Architect will furnish Contractor with one set of digital data files of the Contract Drawings for use in recording information.

    a. See Section 013100 "Project Management and Coordination" for requirements related to use of Architect's digital data files.

C. Format: Identify and date each record Drawing; include the designation "PROJECT RECORD DRAWING" in a prominent location.

1. Record Prints: Organize record prints into manageable sets. Bind each set with durable paper cover sheets. Include identification on cover sheets.
2. Format: Annotated PDF electronic file with comment function enabled.
3. Record Digital Data Files: Organize digital data information into separate electronic files that correspond to each sheet of the Contract Drawings. Name each file with the sheet identification. Include identification in each digital data file.
4. Identification: As follows:

    a. Project name.
    b. Date.
    c. Designation "PROJECT RECORD DRAWINGS."
    d. Name of Architect.
    e. Name of Contractor.

1.5 RECORD SPECIFICATIONS

A. Preparation: Mark Specifications to indicate the actual product installation where installation varies from that indicated in Specifications, addenda, and contract modifications.

1. Give particular attention to information on concealed products and installations that cannot be readily identified and recorded later.
2. Mark copy with the proprietary name and model number of products, materials, and equipment furnished, including substitutions and product options selected.
3. Record the name of manufacturer, supplier, Installer, and other information necessary to provide a record of selections made.

4. For each principal product, indicate whether record Product Data has been submitted in operation and maintenance manuals instead of submitted as record Product Data.
5. Note related Change Orders, record Product Data, and record Drawings where applicable.

B. Format: Submit record Specifications as annotated PDF electronic file scanned PDF electronic file(s) of marked-up paper copy of Specifications.

1.6 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 scanned PDF electronic file(s) of marked-up paper copy of Product Data.

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

1.7 MISCELLANEOUS RECORD SUBMITTALS

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

B. Format: Submit miscellaneous record submittals as PDF electronic file scanned PDF electronic file(s) of marked-up miscellaneous record submittals.

1. Include miscellaneous record submittals directory organized by Specification Section number and title, electronically linked to each item of miscellaneous record submittals.

1.8 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 Architect's reference during normal working hours.

PART 2 - PRODUCTS

PART 3 - EXECUTION

END OF SECTION 017839

SECTION 017900 - DEMONSTRATION AND TRAINING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes administrative and procedural requirements for instructing Owner's personnel, including the following:

1. Instruction in operation and maintenance of systems, subsystems, and equipment.
2. Demonstration and training video recordings.

B. Allowances: Furnish demonstration and training instruction time under the demonstration and training allowance as specified in Section 012100 "Allowances."

C. Unit Price for Instruction Time: Length of instruction time will be measured by actual time spent performing demonstration and training in required location. No payment will be made for time spent assembling educational materials, setting up, or cleaning up. See requirements in Section 012200 "Unit Prices."

1.3 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.

B. Qualification Data: For facilitator, instructor and videographer.

C. Attendance Record: For each training module, submit list of participants and length of instruction time.

D. Evaluations: For each participant and for each training module, submit results and documentation of performance-based test.

1.4 CLOSEOUT SUBMITTALS

A. Demonstration and Training Video Recordings: Submit two copies within seven days of end of each training module.

1. Identification: On each copy, provide an applied label with the following information:

    a. Name of Project.
    b. Name and address of videographer.
    c. Name of Architect.
    d. Name of Construction Manager.
    e. Name of Contractor.
    f. Date of video recording.

2. Transcript: Prepared in PDF electronic format. Include a cover sheet with same label information as the corresponding video recording and a table of contents with links to corresponding training components. Include name of Project and date of video recording on each page.
3. At completion of training, submit complete training manual(s) for Owner's use prepared in same PDF file format required for operation and maintenance manuals specified in Section 017823 "Operation and Maintenance Data."

1.5 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, complying with requirements in Section 014000 "Quality Requirements," experienced in operation and maintenance procedures and training.

C. Videographer Qualifications: A professional videographer who is experienced photographing demonstration and training events similar to those required.

D. Preinstruction Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to demonstration and training including, but not limited to, the following:

1. Inspect and discuss locations and other facilities required for instruction.
2. Review and finalize instruction schedule and verify availability of educational materials, instructors' personnel, audiovisual equipment, and facilities needed to avoid delays.
3. Review required content of instruction.
4. For instruction that must occur outside, review weather and forecasted weather conditions and procedures to follow if conditions are unfavorable.

1.6 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 maintenance manuals. Do not submit instruction program until operation and maintenance data have been reviewed and approved by Architect.

1.7 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.

1.8 PREPARATION

A. Assemble educational materials necessary for instruction, including documentation and training module. Assemble training modules into a training manual organized in coordination with requirements in Section 017823 "Operation and Maintenance Data."

B. Set up instructional equipment at instruction location.

1.9 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.

1. Architect will furnish an instructor to describe basis of system design, operational requirements, criteria, and regulatory requirements.
2. Owner will furnish an instructor to describe Owner's operational philosophy.
3. Owner will furnish Contractor with names and positions of participants.

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 Architect, 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.

E. Evaluation: At conclusion of each training module, assess and document each participant's mastery of module by use of a demonstration performance-based test.

F. Cleanup: Collect used and leftover educational materials and give to Owner. Remove instructional equipment. Restore systems and equipment to condition existing before initial training use.

1.10 DEMONSTRATION AND TRAINING VIDEO RECORDINGS

A. General: Engage a qualified commercial videographer to record demonstration and training video recordings. Record each training module separately. Include classroom instructions and demonstrations, board diagrams, and other visual aids, but not student practice.

1. At beginning of each training module, record each chart containing learning objective and lesson outline.

B. Digital Video Recordings: Provide high-resolution, digital video in MPEG format, produced by a digital camera with minimum sensor resolution of 12 megapixels and capable of recording in full HD modewith vibration reduction technology.

1. Submit video recordings by uploading to web-based Project software site.
2. File Hierarchy: Organize folder structure and file locations according to Project Manual table of contents. Provide complete screen-based menu.
3. File Names: Utilize file names based on name of equipment generally described in video segment, as identified in Project specifications.
4. Contractor and Installer Contact File: Using appropriate software, create a file for inclusion on the equipment demonstration and training recording that describes the following for each Contractor involved on the Project, arranged according to Project Manual table of contents:

a. Name of Contractor/Installer.
b. Business address.
c. Business phone number.
d. Point of contact.
e. Email address.

C. Recording: Mount camera on tripod before starting recording, unless otherwise necessary to adequately cover area of demonstration and training. Display continuous running time.

1. Film training session(s) in segments not to exceed 15 minutes.

a. Produce segments to present a single significant piece of equipment per segment.
b. Organize segments with multiple pieces of equipment to follow order of Project Manual table of contents.
c. Where a training session on a particular piece of equipment exceeds 15 minutes, stop filming and pause training session. Begin training session again upon commencement of new filming segment.

D. Light Levels: Verify light levels are adequate to properly light equipment. Verify equipment markings are clearly visible prior to recording.

1. Furnish additional portable lighting as required.

E. Narration: Describe scenes on video recording by audio narration by microphone while video recording is recorded. Include description of items being viewed.

F. Transcript: Provide a transcript of the narration. Display images and running time captured from videotape opposite the corresponding narration segment.

G. Preproduced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.

PART 2 - PRODUCTS

PART 3 - EXECUTION

END OF SECTION 017900

SECTION 019113 - COMMISSIONING GENERAL REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:
1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 CXA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for actual HVAC&R systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

1.4 COMMISSIONING DOCUMENTATION

A. Review and verify the following information from the Mechanical Contractor for inclusion in the commissioning plan:
1. Plan for delivery and review of submittals and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Review and verify the completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Review and verify of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Review and verify the test and inspection reports and certificates.
7. Corrective action documents.
8. Review and verification of testing, adjusting, and balancing reports.

1.5 SUBMITTALS

A. Certificates of readiness.

B. Certificates of completion of installation, prestart, and startup activities.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION, TESTING AND VERIFICATION

A. The CxA shall review and verify all items listed in Specification 230800. All reviews and documentation shall follow testing and verification listed within that specific sections.

END OF SECTION 019113

SECTION 024119.01 - SELECTIVE ROOF DEMOLITION

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Removal of existing roofing and related materials.

1.2 DEFINITIONS

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

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

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

1.3 SUBMITTALS

A. Schedule of Selective Demolition Activities: Indicate detailed sequence of selective demolition and removal work, with starting and ending dates for each activity, interruption of utility services, and locations of temporary set up areas.

B. Predemolition Photographs or Videotapes: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by selective demolition operations. Submit before Work begins.

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

D. Proposed locations of chutes, dumpsters, cranes, hoists, and other temporary equipment or facilities required for demolition work.

E. Proposed methods for interior and exterior protection and clean-up during removal and re-roofing operations.

F. Provide schedule, updated weekly, indicating areas of roof where demolition will occur. Notify Owner of schedule changes.

1.4 QUALITY ASSURANCE

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 A10.6 and NFPA 241; OSHA, 29 CFR 1926.1101; EPA, NESHAP 40 CFR, Part 60.

C. Comply with Federal, State and Local requirements.

1.5 PROJECT CONDITIONS

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

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

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

1. If materials suspected of containing hazardous materials are encountered, do not disturb; immediately notify Architect and Owner. Owner will remove hazardous materials under a separate contract.

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

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

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

1.6 DEMOLITION AND TRANSPORT

A. Conveyances: Buggies or wheelbarrows used on roofs to transport removed debris to chutes or crane apparatus location shall be of size and design to prevent damage to deck and structure.

B. Chutes: Provide enclosed chutes for debris transfer from roof areas at height of 10-feet or more. Do not allow debris to spill from bottom of chute directly onto ground. Direct chutes into approved construction debris container (dumpster). Control and contain dust and noise from falling debris by use of breaks in vertical alignment of chute or tarps covering dumpster. Provide hose with nozzle near chute outlet to wet debris, as necessary, for dust control.

C. Hoists/Cranes: Provide hoists or cranes to remove debris and transport materials to and from roof. Secure materials to prevent loss during lifting. Place debris transported from roof directly in approved construction debris containers. Provide proper protection of wall areas for entire height directly adjacent to or under area of hoisting.

D. Use of “bobcat” type removal equipment on roof is prohibited.

E. Mechanical cutting equipment: Roof cutting equipment shall be equipped with operable blade depth setting mechanisms to control cutting depth of blade and prevent damage to structural deck during cutting operations.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 GENERAL

A. During removal of existing roofing and related materials, report to Owner areas of damaged, deteriorated, or otherwise unsuitable structural deck or framing materials exposed during work. Do not cover or remove unacceptable deck or framing areas until reviewed by Owner. Provide temporary protection to areas in question. Use care in removal of membrane flashings and decking to prevent damage to substrates.

B. Do not remove more material than can be replaced in one day with the new specified roof system.

C. Take precautions to prevent water on or within existing roof system from migrating into building or new roof system.

D. Review available prints and/or inspect interior of structure to ascertain if electrical or other service has been placed above roof deck or in contact with underside of deck.

E. Set cutting blades of mechanical cutting equipment to proper depth to prevent scoring or damage to structural deck. Use care in removal of membrane flashing to prevent damage to substrates.

F. Control visible emissions during roof removal and at dumpster level.

G. Remove roof materials down to structural deck. Sweep, clean, and vacuum debris from deck surfaces, including flutes of steel deck.

3.3 SELECTIVE DEMOLITION

A. Demolish and remove existing materials as expressly indicated or implied on the drawings. Demolition shall include but may not be limited to the following:

1. Remove existing roofing system(s) and associated components down to structural deck unless otherwise noted in preparation for new systems.
2. Remove abandoned rooftop curbs and penetrations, and associated materials.

3. Remove existing sheet metal caps, fascias, edge metal, counterflashings, penetration flashings, and related sheet metal items unless indicated on Drawings to remain.
4. Remove existing roof drains and associated materials in preparation for new drain bowl assemblies and leader pipe connections.
5. Remove existing conduit supports and duct pipe supports at locations indicated.
6. Remove existing stair assemblies in preparation for new.
7. Remove existing freestanding stair in preparation for new.

B. Removed and Reinstalled Items:

1. Remove, label, and store existing metal wall panels scheduled to be removed and reinstalled.
2. Remove and reinstall existing wall-mounted insulation and light-gauge framing in preparation for flashings.
3. Clean and repair items to functional condition adequate for intended reuse. Paint equipment to match new equipment.
4. Pack or crate items after cleaning and repairing. Identify contents of containers.
5. Protect items from damage during transport and storage.
6. Reinstall items in locations indicated. Comply with installation requirements for new materials and equipment. Provide connections, supports, and miscellaneous materials necessary to make item functional for use indicated.

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

3.4 DISPOSAL OF DEMOLISHED MATERIALS

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

B. Burning: Do not burn demolished materials.

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

3.5 CLEANING

A. Clean demolition materials and debris from roof daily.

B. Clean all surfaces of exposed steel joists, suspended lighting and accessories within the building.

C. Clean site daily to satisfaction of Owner.

D. Dispose of debris and demolition materials at landfill in accordance with applicable regulations.

END OF SECTION 024119

SECTION 055000 - METAL FABRICATIONS

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies requirements for the following Scope of Work:

1. Provide aluminum exterior free standing stair.
2. Provide aluminum exterior stair assemblies to the existing elevated platform.

1.2 SUBMITTALS

A. Shop Drawings: Include plans, elevations, sections, and details of metal fabrications and their connections.

1. Include signature of Contractor and fabricator.
2. Provide stamped and sealed fabrication drawings where indicated.

B. Templates: For anchors and bolts.

PART 2 - PRODUCTS

2.1 METALS

A. Metal Surfaces, General: Provide materials with smooth, flat surfaces without blemishes.

B. Aluminum:

1. Extrusions: ASTM B 221/, alloy 6061 or 6063-T6, mill finish.
2. Pipe: Schedule 40
3. Alloy Rolled Tread Plate: ASTM B 632/B 632M, alloy 6061-T6.

2.2 PAINT

A. Shop Primer for Ferrous Metal: Fast-curing, lead- and chromate-free, universal modified-alkyd primer complying with performance requirements in FS TT-P-664 and compatible with finish paint systems indicated.

B. Galvanizing Repair Paint: SSPC-Paint 20, high-zinc-dust-content paint for regalvanizing welds in steel.

2.3 FASTENERS

A. General: Provide type 304 or 316 stainless-steel fasteners unless otherwise indicated.

B. Steel to steel connections: Bolts; ASTM A 325, endorsed by AISC; sized as indicated in Drawings.

2.4 FABRICATION

A. General: Use connections that maintain structural value of joined pieces.

1. Shear and punch metals cleanly and accurately. Remove burrs.
2. Weld corners and seams continuously. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. Finish exposed welds smooth and blended.
3. Fabricate joints that will be exposed to weather in manner to exclude water, or provide weep holes.
4. Form exposed connections with hairline joints, flush and smooth, using concealed fasteners where possible. Locate joints where least conspicuous.
5. Shop welds shall be in accordance with the American Welding Society (AWS) D1.1.

2.5 FREESTANDING STAIR

A. Stair and Accessories: Comply with IBC, OSHA and CFR requirements. Stairs shall be prefabricated and designed for a single span condition. Stairs and all accessories shall be hot aluminum. Width of stairway shall be 36-inches. Fabricated at a height and depth to clear existing condensate pipes by minimum 6-inches, all sides.

1. Stair and Railings

a. Stairway rails: 5-inch deep channels.
b. Grating: Diamond tread. Openings shall be approximately 3-1/2-inches long by 1-inch wide.
c. Railings: 2-inch nominal pipe. Connections shall be flush-type rail fittings of commercial standard. Welded and ground smooth with railing locks secured with 3/8-inch recessed set screw.

2.6 STAIR ASSEMBLY

A. Stair and Accessories: Comply with IBC, OSHA, and CFA requirements. Stairs shall be prefabricated and designed for a single span condition. Stairs and all accessories shall be aluminum.

1. Stair and Railings

a. Width: 36-inches.

b. Tread: Minimum 12-inch tread, maximum 7-inch rise

c. Stair Rails: 8-inch deep channels.

d. Grating: Diamond tread. Openings shall be approximately 3-1/2-inches long by 1-inch wide.

e. Railings: 2-inch nominal pipe. Connections shall be flush-type rail fittings of commercial standard. Welded and ground smooth with railing locks secured with 3/8-inch recessed set screw.

2.7 FINISHES

A. Ferrous Metals: Finish metal fabrications after assembly. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes. Shop prime ferrous-metal items not indicated to be galvanized.

1. Hot-dip galvanize items indicated to be galvanized to comply with ASTM A 123 or ASTM A 153/A 153M as applicable.
2. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with SSPC-SP 3, "Power Tool Cleaning."
3. Apply shop primer to comply with SSPC-PA 1, "Paint Application Specification No. 1," for shop painting.

B. Non-Ferrous Metals: Provide mill finish.

PART 3 - EXECUTION

3.1 PREPARATION

A. General: Provide anchorage devices and fasteners for securing metal fabrications to in-place construction. Perform cutting, drilling, and fitting required for installing metal fabrications. Set metal fabrications accurately in location, with edges and surfaces level, plumb, and true.

1. Provide temporary bracing or anchors in formwork for items that are to be built into concrete, masonry, or similar construction.
2. Fit exposed connections accurately together. Weld connections, unless otherwise indicated. Do not weld, cut, or abrade galvanized surfaces.

3.2 FREESTANDING STAIR

A. Install continuous walk pads at point of contact with roof.

B. Provide continuous wood blocking within roof system where freestanding stair assembly will come in contact with roof.

C. Install non-penetrating stair platform over existing condensate pipes with minimum 6-inch clearance on all sides.

3.3 STAIR ASSEMBLY

A. Provide continuous walkway pad at point of contact with roof.

B. Provide continuous wood blocking within roof system where freestanding stair assembly will come in contact with roof.

C. Provide continuous angle welded to existing tube steel. Fasten stair assembly to continuous angle.

3.4 SURFACE CORRECTION – FERROUS METALS

A. Touch up surfaces and finishes after erection.

1. Shop painted Surfaces: Clean field welds, bolted connections, and abraded areas and touch up paint with same material as used for surrounding surfaces.
2. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing to comply with ASTM A 780.

END OF SECTION 055000

SECTION 055213 - PIPE AND TUBE RAILINGS

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. Aluminum pipe railings.

1.3 COORDINATION

A. Coordinate installation of anchorages for railings. 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.

B. Schedule installation so wall attachments are made only to completed walls. Do not support railings temporarily by any means that do not satisfy structural performance requirements.

1.4 ACTION SUBMITTALS

A. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

B. Delegated-Design Submittal: For railings, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Protect mechanical finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

1.6 FIELD CONDITIONS

A. Field Measurements: Verify actual locations of walls and other construction contiguous with metal fabrications by field measurements before fabrication.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Aluminum Pipe and Tube Railings:

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:

B. Source Limitations: Obtain each type of railing from single source from single manufacturer.

2.2 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design railings, including attachment to building construction.

B. Structural Performance: Railings, including attachment to building construction, shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1. Handrails and Top Rails of Guards:

a. Uniform load of 50 lbf/ ft. applied in any direction.
b. Concentrated load of 200 lbf applied in any direction.
c. Uniform and concentrated loads need not be assumed to act concurrently.

2. Infill of Guards:

a. Concentrated load of 50 lbf applied horizontally on an area of 1 sq. ft..
b. Infill load and other loads need not be assumed to act concurrently.

C. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F, ambient; 180 deg F,material surfaces.

2.3 METALS, GENERAL

A. Metal Surfaces, General: Provide materials with smooth surfaces, without seam marks, roller marks, rolled trade names, stains, discolorations, or blemishes.

B. Brackets, Flanges, and Anchors: Cast or formed metal of same type of material and finish as supported rails unless otherwise indicated.

1. Provide type of bracket with flange tapped for concealed anchorage to threaded hanger bolt and that provides 1-1/2-inch clearance from inside face of handrail to finished wall surface.

2.4 ALUMINUM

A. Aluminum, General: Provide alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated, and with not less than the strength and durability properties of alloy and temper designated below for each aluminum form required.

B. Extruded Tubing: ASTM B 221, Alloy 6063-T5/T52.

C. Extruded Structural Pipe: ASTM B 429/B 429M, Alloy 6063-T6.

1. Provide Standard Weight (Schedule 40) pipe unless otherwise indicated.

D. Drawn Seamless Tubing: ASTM B 210, Alloy 6063-T832.

E. Plate and Sheet: ASTM B 209, Alloy 6061-T6.

F. Die and Hand Forgings: ASTM B 247, Alloy 6061-T6.

G. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

2.5 FASTENERS

A. General: Provide the following:

1. Aluminum Railings: Type 316 stainless-steel fasteners.
2. Provide exposed fasteners with finish matching appearance, including color and texture, of railings.

B. Fasteners for Anchoring Railings to Other Construction: Select fasteners of type, grade, and class required to produce connections suitable for anchoring railings to other types of construction indicated[and capable of withstanding design loads].

2.6 MISCELLANEOUS MATERIALS

A. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.

1. For aluminum railings, provide type and alloy as recommended by producer of metal to be welded and as required for color match, strength, and compatibility in fabricated items.

B. Etching Cleaner for Galvanized Metal: Complying with MPI#25.

2.7 FABRICATION

A. General: Fabricate railings to comply with requirements indicated for design, dimensions, member sizes and spacing, details, finish, and anchorage, but not less than that required to support structural loads.

B. Shop assemble railings to greatest extent possible to minimize field splicing and assembly. Disassemble units only as necessary for shipping and handling limitations. Clearly mark units for reassembly and coordinated installation. Use connections that maintain structural value of joined pieces.

C. Cut, drill, and punch metals cleanly and accurately. Remove burrs and ease edges to a radius of approximately 1/32 inch unless otherwise indicated. Remove sharp or rough areas on exposed surfaces.

D. Form work true to line and level with accurate angles and surfaces.

E. Fabricate connections that are exposed to weather in a manner that excludes water. Provide weep holes where water may accumulate.

F. Cut, reinforce, drill, and tap as indicated to receive finish hardware, screws, and similar items.

G. Connections: Fabricate railings with welded connections unless otherwise indicated.

H. Welded Connections: Cope components at connections to provide close fit, or use fittings designed for this purpose. Weld all around at connections, including at fittings.

1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
2. Obtain fusion without undercut or overlap.
3. Remove flux immediately.
4. At exposed connections, finish exposed surfaces smooth and blended so no roughness shows after finishing and welded surface matches contours of adjoining surfaces.

I. Welded Connections for Aluminum Pipe: Fabricate railings to interconnect members with concealed internal welds that eliminate surface grinding, using manufacturer's standard system of sleeve and socket fittings.

J. Nonwelded Connections: Connect members with concealed mechanical fasteners and fittings. Fabricate members and fittings to produce flush, smooth, rigid, hairline joints.

1. Fabricate splice joints for field connection using an epoxy structural adhesive if this is manufacturer's standard splicing method.

K. Form Changes in Direction as Follows:

1. By radius bends of radius indicated.

L. For changes in direction made by bending, use jigs to produce uniform curvature for each repetitive configuration required. Maintain cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of components.

M. Close exposed ends of railing members with prefabricated end fittings.

N. Provide wall returns at ends of wall-mounted handrails unless otherwise indicated. Close ends of returns unless clearance between end of rail and wall is 1/4 inch or less.

O. Brackets, Flanges, Fittings, and Anchors: Provide wall brackets, flanges, miscellaneous fittings, and anchors to interconnect railing members to other work unless otherwise indicated.

P. For removable railing posts, fabricate slip-fit sockets from stainless-steel tube or pipe whose ID is sized for a close fit with posts; limit movement of post without lateral load, measured at top, to not more than one-fortieth of post height. Provide socket covers designed and fabricated to resist being dislodged.

1. Provide chain with eye, snap hook, and staple across gaps formed by removable railing sections at locations indicated. Fabricate from same metal as railings.

Q. Toe Boards: Where indicated, provide toe boards at railings around openings and at edge of open-sided floors and platforms. Fabricate to dimensions and details indicated.

2.8 ALUMINUM FINISHES

A. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are unacceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.

B. Mill Finish: AA-M12, nonspecular as fabricated.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Fit exposed connections together to form tight, hairline joints.

B. Perform cutting, drilling, and fitting required for installing railings. Set railings accurately in location, alignment, and elevation; measured from established lines and levels and free of rack.

1. Do not weld, cut, or abrade surfaces of railing components that are coated or finished after fabrication and that are intended for field connection by mechanical or other means without further cutting or fitting.
2. Set posts plumb within a tolerance of 1/16 inch in 3 feet.
3. Align rails so variations from level for horizontal members and variations from parallel with rake of steps and ramps for sloping members do not exceed 1/4 inch in 12 feet.

C. Control of Corrosion: Prevent galvanic action and other forms of corrosion by insulating metals and other materials from direct contact with incompatible materials.

1. Coat, with a heavy coat of bituminous paint, concealed surfaces of aluminum that are in contact with grout, concrete, masonry, wood, or dissimilar metals.

D. Adjust railings before anchoring to ensure matching alignment at abutting joints.

E. Fastening to In-Place Construction: Use anchorage devices and fasteners where necessary for securing railings and for properly transferring loads to in-place construction.

3.2 RAILING CONNECTIONS

A. Nonwelded Connections: Use mechanical or adhesive joints for permanently connecting railing components. Seal recessed holes of exposed locking screws using plastic cement filler colored to match finish of railings.

B. Welded Connections: Use fully welded joints for permanently connecting railing components. Comply with requirements for welded connections in "Fabrication" Article whether welding is performed in the shop or in the field.

C. Expansion Joints: Install expansion joints at locations indicated but not farther apart than required to accommodate thermal movement. Provide slip-joint internal sleeve extending 2 inches beyond joint on either side, fasten internal sleeve securely to one side, and locate joint within 6 inches of post.

3.3 ANCHORING POSTS

A. Anchor posts to metal surfaces with oval flanges, angle type, or floor type as required by conditions, connected to posts and to metal supporting members as follows:

1. For aluminum pipe railings, attach posts using fittings designed and engineered for this purpose.

B. Install removable railing sections, where indicated, in slip-fit metal sockets cast in concrete.

3.4 ATTACHING RAILINGS

A. Anchor railing ends at walls with round flanges anchored to wall construction and welded to railing ends.

B. Anchor railing ends to metal surfaces with flanges bolted to metal surfaces and welded to railing ends.

C. Attach railings to wall with wall brackets, except where end flanges are used. Locate brackets as indicated or, if not indicated, at spacing required to support structural loads.

3.5 ADJUSTING AND CLEANING

A. Clean aluminum by washing thoroughly with clean water and soap and rinsing with clean water.

3.6 PROTECTION

A. Protect finishes of railings from damage during construction period with temporary protective coverings approved by railing manufacturer. Remove protective coverings at time of Substantial Completion.

END OF SECTION 055213

SECTION 061000 - ROUGH CARPENTRY

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies requirements for the following Scope of Work:

1. Provide wood blocking, supports, shims, and other miscellaneous assemblies as indicated.

1.2 SUBMITTALS

A. Product Data: For each item specified in Part 2 of this Section.

1.3 PROJECT CONDITIONS

A. Wood blocking shown on Drawings may be greater or less than quantities required to match insulation thickness. Include required quantities in Base Bid.

B. Maintain constant perimeter heights to provide equal edge metal and fascia reveals.

C. Store wood to prevent distortion and to protect from atmospheric moisture.

D. Dimensional lumber and plywood shall be kiln dried unless otherwise indicated. If pressure treated lumber is required by the roof membrane manufacturer, additional compensation will not be considered. Additionally, if pressure treated wood is used, wood shall be separated from all metal components to avoid galvanic corrosion.

PART 2 - PRODUCTS

2.1 WOOD PRODUCTS, GENERAL

A. Lumber: DOC PS 20 and applicable rules of lumber grading agencies certified by ALSC.

1. Factory mark each piece of lumber with grade stamp of grading agency.
2. Maximum moisture content at time of dressing: 19 percent, maximum, for 2-inch nominal thickness or less.

B. Wood blocking and framing shall construction or No. 2 grade and any of following species:

1. Douglas fir-larch, Douglas fir-larch (north), or Douglas fir-south; NLGA, WCLIB, or WWPA.
2. Hem-fir or Hem-fir (north); NLGA, WCLIB, or WWPA.
3. Southern pine; SPIB.

4. Spruce-pine-fir (south) or Spruce-pine-fir; NELMA, NLGA, WCLIB, or WWPA.

2.2 DECKING AND SHEATHING

A. Plywood Sheathing: APA PS 1 Exposure 1 sheathing, 3/4-inch thick.

2.3 FASTENERS

A. Fasteners, washers, and accessories: Stainless steel or galvanized steel.

1. Galvanized: ASTM A 153, hot-dip method. Electrogalvanized items unacceptable.

B. Wood-to-wood connections: Galvanized, annular-threaded or ring-shanked common nails, 3-inches long.

C. Termination bar to wood: Number 12, self-drilling, self-tapping screws of sufficient length to penetrate substrate 1-1/2-inches minimum.

D. Wood blocking to steel deck and steel framing: Number 14, self-drilling, self-tapping screws, factory treated with fluorocarbon coating or stainless steel, of sufficient length to penetrate upper flutes of steel deck or steel framing 1-inch minimum and 1-1/4-inches maximum.

E. Plywood to brick masonry or concrete walls: 1/4-inch diameter, 2-inch long drive pin anchors, with zinc sheath and stainless steel pin.

F. Dimension lumber to masonry or concrete: Masonry screws with high-low threads for tapping concrete and corrosion resistant coating; 1/4-inch diameter; Tapcon, by ITW Buildex, or approved equal.

2.4 ACCESSORIES

A. Self-Adhering Modified Bitumen: See Division 07 Section “Flashing and Sheet Metal.”

B. Temporary Membrane: See Division 07 Section “Cold Liquid Applied Roofing.”

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Selection of lumber pieces:

1. Select members so that knots and obvious defects will not interfere with proper fastening and will allow making of proper connections. Cut out and discard defects that render piece unable to serve intended function.
2. Lumber may be rejected for excessive warp, twist, bow, crook, mildew, fungus, mold, or moisture content, as well as for improper cutting and fitting.

B. Set rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit rough carpentry to other construction; scribe and cope as needed for accurate fit. Locate nailers, blocking, and similar supports to comply with requirements for attaching other construction.

C. Comply with Factory Mutual (FM) Data Sheet 1-49 for anchoring perimeter blocking. Reduce fastener spacing by half within 8-feet of exterior corners.

D. Cut butt joints in woodwork to provide smooth, uniform line without irregularities. Stagger butt joints at multiple layers of blocking, layer to layer. Gap joints 1/8-inch. Minimum length of any individual piece of woodwork at perimeter edge shall be 3-feet, with minimum of 2 fasteners per piece.

E. Overlap wood blocking joints at corners from layer to layer.

F. Protect installed wood from moisture and weather. Wood degraded by exposure shall be rejected.

3.2 FASTENING OF WOODWORK

A. General:

1. Countersink fasteners below top plane of nailers.
2. Achieve 1-1/4-inch minimum penetration into substrate when fastening 2x lumber to brick, structural concrete, or 2x lumber. Provide 1-inch minimum and 1-1/2-inches maximum penetration of metal decks.
3. Provide 2 rows of fasteners at the specified frequency for wood blocking 2-inches by 8-inches nominal and wider.
4. When attaching wood to concrete or masonry, through-drill wood 1/16-inch larger than fastener shank.
5. Re-secure existing wood blocking scheduled for reuse with appropriate fasteners spaced at 48-inches on center, staggered off centerline.

B. Wood blocking:

1. To wood blocking: With annular-threaded, ring-shank nails, 12-inches on center, maximum, and staggered slightly off centerline of member being installed.
2. To concrete/masonry substrates: With screws spaced 16-inches on center maximum and staggered slightly off centerline of member being secured.
3. At deck penetrations to steel framing and steel decking: With self-drilling, self-tapping screws spaced at 16-inches on center maximum in staggered pattern.
4. For nailer to nailer connections, penetrate member being fastened to 3/4 thickness of member. Fasten 16-inches on center, staggered.

C. Plywood:

1. To concrete/masonry walls: With drive pins spaced at 8-inches on center vertically and 16-inches on center horizontally staggered from row to row. Predrill pilot holes in accordance with fastener manufacturer's printed instructions.
2. To wood blocking: With nails spaced at 8-inches on center along each framing member.

    a. Countersink fasteners below top plane of plywood.
    b. Provide 1/8-inch gap between successive sections of plywood. Align finished surfaces to vary not more than 1/16-inch from plane of surfaces of adjacent units.
    c. Place panels with long dimension perpendicular to support.
    d. Install roof deck panels in staggered array, with panel ends in successive rows being offset. Minimum panel placement size shall be 48-inches by 48-inches. Each panel shall span minimum of 3 supports.
    e. Center joints accurately over support.

END OF SECTION 061000

SECTION 072200 - ROOF AND DECK INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. This section specifies requirements for the following Scope of Work:

1. Provide tapered and flat thermal insulation and cover board.
2. Provide insulation crickets, fillers, and cants.

1.2 SYSTEM DESCRIPTION

A. Tapered Insulation System:

1. Provide minimum insulation thickness as specified.
2. The maximum thickness for any given insulation board or layer shall be 3-inches.
3. Provide minimum average aged R-Value of 30 throughout roof areas.
4. Maintain constant perimeter height at edges of each roof section.
5. Utilize existing drain locations as indicated on Drawings.
6. Provide crickets and saddles between interior drainage points. Cricket width shall be as required to provide positive slope to drain but in no case less than 8-foot wide unless specifically indicated otherwise.
7. Provide 8-foot by 8-foot sumps at each drain location.

1.3 SUBMITTALS

A. Product Data: For each product indicated in Part 2 of this Section.

B. Manufacturer’s full size tapered insulation/cricket drawing with the following:

1. Outline of roof area with drain and major penetration locations.
2. Profile of tapered sections to include crickets.
3. Average R-value of system.

C. Certifications: Provide documentation for requirements described in Paragraph 1.4, Quality Assurance.

D. Insulation attachment pattern: Provide a drawing showing typical fastener pattern and frequency at field, corners, and edges.

1.4 QUALITY ASSURANCE

A. Fire-Test-Response Characteristics: Provide insulation and related materials with fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84 for surface-burning characteristics, by UL or another testing and inspecting agency acceptable to authorities having jurisdiction. Identify materials with appropriate markings of applicable testing and inspecting agency.

B. Securement: Fasten or secure components of system to meet or exceed requirements of FMG Data Sheets 1-28 and 1-29. Comply with requirements to achieve wind uplift rating of 1-90.

C. Insulation products incorporated into roof system shall be included in roof membrane manufacturer's system warranty. Provide documentation from membrane manufacturer that proposed insulation will be included in required warranty.

D. Tapered insulation plan in Drawings is a conceptual configuration showing basic design intent. Do not interpret Drawings as approved tapered insulation layout plan.

PART 2 - PRODUCTS

2.1 INSULATION BOARDS

A. Roof insulation system materials shall be manufactured by or acceptable to roof membrane manufacturer for inclusion in full system warranty to be issued by manufacturer.

B. Polyisocyanurate: ASTM C 1289, Type II; Class I, Grade 2.

1. Flat Board Stock: Minimum thickness 3.0-inches.
2. Tapered System: 1/4-inch per foot slope, to provide consistent slope; minimum thickness of tapered isocyanurate shall be 1/2-inch.
3. Crickets:1/2-inch per foot, minimum slope.
4. Board size, maximum:

    a. For Adhered Installation: 4-feet by 4-feet.
    b. For Mechanically Attached Insulation: 4-feet by 8-feet.

C. Cover Board: Fiberglass faced, gypsum board with moisture resistant core; ASTM C 1177.

1. Thickness: 1/2-inch.
2. DensDeck Prime by Georgia Pacific, or approved substitute.

2.2 MECHANICAL INSULATION

A. Insulation for drain bowls and leader piping: fibrous glass batt type with premolded polyvinyl chloride jackets. Seaming tape for jacket seams shall be as supplied by insulation jacket manufacturer. Minimum thickness 1-inch.

B. Fiberglass batt insulation for use at locations other than hot pipes: Conforming to ASTM C 665, Type II, Class C and E84, I, 3-inches thick.

2.3 ACCESSORIES

A. Adhesive: One- or two-part; spray applied polyurethane foam approved by membrane manufacturer.

B. Fasteners

1. Insulation Fasteners: Number 12, self-drilling, self-tapping screws; sufficient length to penetrate top flange of steel decking by 1-inch minimum and 1-1/4-inches maximum; with fluorocarbon coating complying with FMG 4470.
2. Stress Plates: Nominal 3-inch diameter, 26 gauge galvalume coated steel.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ensure that surfaces to receive insulation are clean and dry. If necessary, provide equipment to dry surface prior to application. Do not dry with open flames.

B. Remove dirt, debris, and dust from substrates by brooming or vacuuming. Clean dirt and debris from between steel deck ribs.

C. Provide roof insulation boards free of defects, including, but not limited to, broken corners, improperly adhered skins, excessive moisture content (if insulation surface “foams” when hot bitumen is applied, excessive moisture is present), dimensional irregularities, or other defects that may adversely affect replacement roof system. Mark defective insulation boards permanently and remove from site.

3.2 ROOF INSULATION INSTALLATION

A. Mechanical Attachment:

1. Secure base layer of insulation to steel roof decks using specified fasteners. Stagger end joints to middle of long dimension of insulation boards. Install fasteners at a rate of 1 fastener per 2 square feet (16 fasteners per 4-feet by 8-feet board) in the field of the roof. Increase fasteners to 24 fasteners per 4-feet by 8-feet board 8 feet minimum from the building perimeter. Further increase fastener frequency to 32 fasteners per 4-feet by 8-feet board for minimum of 8-feet in each direction from building corners where parapets do not exceed 3-feet in height. Drive fasteners straight, perpendicular to insulation. Install fasteners in accordance with the pattern established by the FMG Approval Guide. Adhere subsequent layers of insulation in adhesive.
2. Install insulation boards with minimum surface area of 16 square feet within 8-feet of building perimeters. Minimum dimension on cut insulation boards in field of roof shall be 12-inches, with minimum surface area of 2 square feet.

B. Adhesive Attachment:

1. Apply adhesive to substrate using full coverage method in accordance with manufacturer's requirements and recommendations.
2. Set boards in adhesive, butting edges tightly. Stagger joints of insulation and coverboard within each layer. Offset joints between layers 12-inches minimum. Fill gaps greater than 1/4-inch.
3. Walk in boards to ensure adhesion and provide smooth top plane of insulation.

C. Utilize tapered edge strips and filler boards at drain sump locations. Place taper from surrounding insulation system down to drain bowl locations, providing 8-foot by 8-foot minimum drain sumps.

3.3 PIPE INSULATION INSTALLATION

A. Install insulation and jackets at drain bowls as indicated on Drawings, in accordance with manufacturer's printed instructions. Refer to Division 22, "Roof Drains" for additional information

END OF SECTION 072200

SECTION 075216 - MODIFIED BITUMINOUS MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide new 2-ply SBS modified bitumen roof membrane with liquid-applied flashing, and associated roof system components.

1.2 SUBMITTALS

A. Certificates of Compliance: Roof membrane manufacturer's certification that materials are chemically and physically compatible with each other and suitable for inclusion in roof system and are acceptable for warranty specified. Do not submit materials without obtaining membrane manufacturer's written certification. Explicitly identify in writing, difference between manufacturer's written requirements and these specifications, and membrane manufacturer’s approval of proposed asphalt source.

B. Product data: For each product specified in Part 2.

C. Sample: Roof membrane manufacturer’s warranty.

D. Contractor’s letter certifying a minimum of 5-years commercial built-up roofing experience with list of project references, including names and phone numbers.

1.3 REFERENCES

A. Roof construction and materials shall comply with these specifications and the latest editions of the following:

1. Sheet Metal and Air Conditioning Contractors National Association (SMACNA)
2. The National Roofing Contractors Association (NRCA) “Roofing and Waterproofing Manual”
3. The Asphalt Roofing Manufacturers Association (ARMA).
4. Factory Mutual Global (FMG) publications “Loss Prevention Data for Roofing Contractors” and “Building Materials Approval Guide”
5. Underwriters Laboratories, Inc. “Roofing Materials and Systems Directory”
6. All work shall be performed in accordance with the International Building Code (IBC) in effect at the time of Bid and applicable Federal, State, and local code amendments, requirements, and publications.

1.4 QUALITY ASSURANCE

A. Manufacturer Approval:

1. Installer Qualifications: Approved by manufacturer to install manufacturer’s products.
2. Source Limitations: To greatest extent possible, obtain auxiliary materials for roofing system from roofing membrane manufacturer. Provide letter of acceptance from manufacturer for auxiliary materials from other sources.
3. System Approval: Provide statement from manufacturer that specified roof system meets requirements for requested warranty.
4. Final Roof Inspection: Arrange for roofing system manufacturer's technical personnel to inspect roofing installation on completion and submit report to Architect.
5. Comply with manufacturer's written instruction and these Specifications for roofing and associated work. Provide skilled tradesmen experienced in installation of 2-ply SBS modified bitumen roofing systems. Foreman shall have a minimum of 5 years of previous SBS membrane installation experience.
6. Identify in writing specific contract requirements that are not approved or warrantable by manufacturer.

B. Minimum quality standards: Comply with NRCA/ARMA publications “Quality Control Guidelines for the Application of Built-up Roofing” and “Quality Control Guidelines for Polymer Modified Bitumen Roofing”. Standards within these specifications that exceed NRCA/ARMA shall prevail.

C. Project construction will be monitored and evaluated by the Owner or Owner’s Representative for compliance with the Contract Documents.

D. Do not install roofing systems or sealants during precipitation, including fog, or when air temperature is below 40° F (4° C) or is expected to go below 40° F (4° C) during application, or when there is ice, frost, moisture, or visible dampness on the roof.

E. Phased or temporary construction will only be permitted as specified. Schedule, execute, and coordinate work on a daily basis so that components are installed completely and permanently as specified.

F. Schedule, coordinate, and execute work to avoid traffic on completed roof areas. Coordinate work to prevent this situation by working away from completed roof areas, toward roof edges and access ways.

G. Roofing that is removed shall be made 100% weathertight in the same day’s operations.

1.5 GUARANTEES AND WARRANTIES

A. Provide complete roof system, including temporary roof membrane, liquid flashing, and insulation, to be covered by roof membrane manufacturer’s system warranty. Provide materials not included in Specifications where required by manufacturer to obtain requested warranty, without additional charge to Owner.

B. Roof membrane manufacturer’s system warranty meeting following minimum criteria:

1. Coverage to repair damage to system components resulting from leaks due to failure of materials or workmanship.
2. Non-prorated, non-penal sum (no dollar limit), 20-year warranty period.
3. Coverage of cost of removal and replacement of wet or damaged insulation due to failure of materials or workmanship.
4. No exclusion from coverage for damage to roof system from wind gusts less than 55 miles per hour.

C. The Contractor shall schedule periodic site visits by the Membrane Manufacturer providing the warranty during the construction period. Announce the Manufacturer's site visit (inspection) to the Owner 72 hours prior to its occurrence. Visits by the Manufacturer's representative shall be made prior to project start-up, one week into the start of construction, with inspections prior to the installation of the membrane surfacing, at project completion, and as requested by the Owner. The Contractor shall provide the Owner a copy of the Manufacturer's written report for each inspection, indicating Manufacturer's comments pertaining to installation of materials and any corrective recommendations. In addition, the Contractor is responsible to notify and obtain acceptance from the Membrane Manufacturer on detail changes that may affect the roof system warranty.

D. Contractor's Guarantee: Submit a full Contractor's Guarantee of the Work to be free from defect in materials and workmanship upon Substantial Completion, and prior to final payment. This Guarantee shall be for a period of five (5) years from the date of Substantial Completion and shall be signed by a Principal of the Contractor's firm, and sealed if a corporation.

PART 2 - PRODUCTS

2.1 PRODUCT PERFORMANCE

A. Provide products fully compatible with substrates and other assembly components. Materials shall be approved for UL Class A fire rating service and meet FM 1-90 (minimum) wind uplift requirements.

B. Modified bitumen products and systems shall comply with test methods designated in ASTM D 5147-91.

2.2 MODIFIED BITUMEN SHEETS

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

1. Soprema, Inc.
2. Siplast, Inc.
3. Johns Manville
4. Firestone
5. GAF

B. Roofing Membrane Base Ply: ASTM D 6164, Grade S, Type I or II, polyester-reinforced, SBS-modified asphalt sheet; smooth surfaced; suitable for application with cold-applied adhesive.

C. Roofing Membrane Cap Sheet: ASTM D 6164, Grade G, Type I or II, polyester-reinforced, SBS-modified asphalt sheet; granular surfaced; fire rated; suitable for application with cold-applied adhesive; white granules.

D. Base Flashing: Liquid-applied PMMA flashings as specified in 075600 “Cold Liquid-Applied Membrane Roofing”.

2.3 AUXILIARY ROOFING MATERIALS

A. General: Auxiliary materials recommended by roofing system manufacturer for intended use and compatible with roofing membrane.

B. Asphalt Primer: ASTM D 41.

C. Roofing Asphalt: ASTM D 312, Type IV.

D. Cold-Applied Adhesive: Roofing system manufacturer's standard asphalt-based, one- or two-part, asbestos-free, cold-applied SBS modified bitumen adhesive specially formulated for compatibility and use with roofing membrane.

E. Sealant: One-part polyurethane, gunnable grade, high performance elastomeric sealant: ASTM C 920, Type S, Grade NS, Class 25, use NT.

F. Self-adhering Membrane: See Division 07 Section “Flashing and Sheet Metal.”

G. Temporary Membrane/1-Ply SBS Membrane (Alternate No. 1): See Division 07 Section “Cold Liquid Applied Membrane Roofing.”

H. Lap Bleed Finish Granules: Ceramic granules sized and colored to match flashing sheet surfacing as supplied by membrane manufacturer.

I. Temporary Foam Night Seal: Two-part polyurethane foam pack: Roofpak by Dow Chemical Company or accepted substitute.

J. Lead Sheet: See Division 07 Section “Flashing and Sheet Metal.”

K. Walkways

1. Cap Sheet Walkways: SBS-modified asphalt sheet; granular surfaced as specified in this Section.

L. Elastomeric Coatings: See Division 09 Section “Elastomeric Coatings.”

PART 3 - EXECUTION

3.1 PREPARATION

A. Verify insulation boards are installed smoothly and evenly, and are not broken, cracked, or curled. Insulation shall be roofed over on same day as it is installed.

B. Verify that drains, curbs, cants, perimeter blocking, wall flashing substrates, roof penetrating elements and other items necessary to begin installation of membrane are installed.

C. Do not cut or modify bituminous products with solvent or dilutant.

D. Prime masonry, concrete, and sheet metal surfaces in contact with bituminous materials, including sheet metal flanges (both sides) and lead sheet at drain sumps (both sides) with asphaltic primer prior to roofing or flashing installation. Allow primer to dry thoroughly prior to installing flashings.

E. Do not deliver to site or install a material or system that has not been approved. Remove materials installed without prior approval upon Owner's request.

F. Surfaces to receive new membrane and flashings shall be clean and thoroughly dry. Should surface moisture such as dew exist, provide necessary equipment to dry surface prior to application. Do not dry with open flames.

G. Ensure that SBS modified bitumen products are sufficiently warmed prior to use when ambient overnight temperatures are below 40 degrees F.

H. All reinforcing plies, self-adhering membrane envelopes, and base flashings must be installed concurrently with roof membrane installation work, and must be complete and up to date by end of each work week (i.e. Friday or next working day).

3.2 BASE PLY SHEET INSTALLATION

A. Sheets shall be laid parallel to longest dimension of tapered area to be roofed and/or perpendicular to slope of area. Application shall start at low point of area working to high point. Laps shall be parallel to slope of short dimension of tapered area and in no case shall laps buck flow of water.

B. Unroll dry membrane on substrate and align with adjacent sheet, providing 3-inch side laps and 6-inch end laps. Stagger end laps of adjacent sheets by 12-inches minimum. Reroll approximately one-half of dry membrane sheet while maintaining alignment.

C. Unroll and embed membrane into adhesive. Apply even pressure with stiff bristle broom directly behind roll to ensure full adhesion. Repeat procedure for other half of roll.

D. Membrane sheets shall be applied free of wrinkles, creases, fishmouths, or voids. Maintain alignment of sheets utilizing marked lap lines. Should lap lines become misaligned while unrolling, cut sheet and establish a new end lap. Do not attempt to realign a partially adhered membrane roll.

E. Inspect ply sheet application for defects. Cut wrinkles, creases, and fishmouths to relax membrane. Apply a full width strip of base ply membrane over defect lapped a minimum of 3-inches beyond cut. Unbonded lap seams of more than 1/2-inch wide shall be embedded in cold adhesive troweled under unbonded membrane or heat welded.

3.3 MODIFIED CAP SHEET INSTALLATION

A. Verify that all repairs have been made to the field membrane. Surfaces should be free of sawdust, dirt, insulation debris, and other contaminants prior to starting installation.

B. Cap sheets shall be laid perpendicular to the flow of water starting at the low point of the area and working to the high point. Unroll dry membrane and allow it to relax. Provide 3-inch side laps and 6-inch end laps, and stagger end laps of adjacent cap sheets by 24-inches. Align the granulated side of the sheet over the selvage side of the adjacent sheet. While maintaining alignment, reroll approximately one-half of the dry membrane sheet.

C. Apply adhesive at the rate recommended by the manufacturer. Apply even pressure with stiff bristle broom directly behind roll to ensure full adhesion. Avoid excessive bleed out of more than 1-inch. Distribute loose granules into adhesive bleed out directly behind membrane applicable to ensure complete color uniformity of cap sheet surface. Repeat procedure for the other half of the roll.

D. Membrane cap sheets shall be applied free of wrinkles, creases, fishmouths, or voids. Maintain alignment of sheets utilizing marked lap lines. Should the lap lines become misaligned while unrolling, cut the sheet and establish a new end lap. Do not attempt to realign a partially adhered membrane roll.

E. Inspect cap sheet application for defects. Cut wrinkles, creases, and fishmouths to relax the membrane. Apply a full width strip of cap sheet membrane over the defect in a full bed of cold adhesive and lapped a minimum of 6-inches beyond the cut. Unbonded lap seams of more than 1/2-inch wide shall be embedded in cold adhesive troweled under the unbonded membrane. Reapply granules to repairs as needed.

3.4 SELF-ADHERING MEMBRANE INSTALLATION

A. Condition surfaces with primer at walls and perimeter elements to receive membrane as recommended by membrane manufacturer. Do not prime more than can be covered by sheet installation in one day.

B. Install self-adhering modified bitumen membrane as detailed.

C. Cut modified bitumen into lengths not to exceed 8-feet.

D. Remove release paper backing, set membrane into place, provide minimum 3-inch head laps, and roll down smooth with metal roller.

E. Lap membrane over vertical base flashings and substrate surfaces 3-inches minimum or as indicated in Drawings.

3.5 TEMPORARY MEMBRANE/1-PLY SBS MEMBRANE (ALT. NO. 1) INSTALLATION

A. See Division 07 Section “Cold Liquid-Applied Roofing.”

3.6 BASE FLASHING INSTALLATION

A. See Division 07 Section “Cold Liquid-Applied Roofing” for liquid flashing installation.

3.7 DRAIN FLASHING

A. Apply base ply over drain bowl flange (beneath clamping ring) as detailed. Trim flush with inside diameter of drain bowl as detailed.

B. Install lead flashing sheet at drains in full bed of adhesive as detailed. Cut single piece of reinforcing ply membrane 39-inches by 39-inches and chalk diagonal lines to establish center of sheet. Cut hole at center of this target sheet to provide minimum of 1-inch of membrane inside clamping ring.

C. Install target sheet centered over drain bowl in a full bed of modified bitumen adhesive at specified rate and directly to primed lead sheet and 4-inches minimum onto field membrane.

D. Offset cap sheet from edge of drain approximately 6-inches so that no seams are installed under clamping ring.

3.8 WALKWAY PAD

A. Anticipate 500 linear feet of walkway pad installation. Actual locations of walkway to be determined by Owner.

B. Provide membrane protection pads at areas to receive foot traffic, such as roof access doors, hatches, ladders, and major rooftop equipment units or as otherwise indicated by the Owner.

C. For cap sheets used as walkways, use full width of roll cut in maximum 5-foot lengths. Provide 6-inch gaps between adjacent pieces. Ensure full adhesion.

3.9 TEMPORARY PROTECTION

A. Unfinished perimeter and penetration components: Provide temporary waterstops adequate to prevent moisture intrusion into newly installed work around exposed edges and incomplete flashing locations. Remove temporary materials completely prior to continuing with subsequent work.

B. Tie-ins: Provide temporary waterstops at deck and tie-ins between newly installed and existing membrane as detailed. Inspect tie-ins thoroughly and repair as needed to provide watertight assembly prior to leaving site.

END OF SECTION 075216

SECTION 075600 - COLD LIQUID APPLIED MEMBRANE ROOFING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide fully reinforced liquid-applied PMMA flashings (Base Bid).
2. Provide a complete system, including fully reinforced field and flashing liquid-applied PMMA membrane, in lieu of modified bitumen roof system (Alternative No. 1).

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For roofing system. Include plans, elevations, sections, details, and attachments to other work.

C. Certifications: Provide documentation for requirements outlined in Paragraph 1.4, Quality Assurance.

D. Sample roof membrane manufacturer's warranty.

E. Contractor's letter certifying a minimum of 5-years commercial roofing experience to include 3 projects of similar size and scope to this project completed in the last 5 years. Provide a list of project references, including names and phone numbers.

1.3 QUALITY ASSURANCE

A. Manufacturer approval:

1. Installer Qualifications: Approved by manufacturer to install manufacturer's products.
2. Source Limitations: To greatest extent possible, obtain components for roofing system from roofing system manufacturer. Provide letter of acceptance from manufacturer for components, including insulation products from other sources.
3. System approval: Provide statement from manufacturer that specified roof system meets requirements for requested warranty.
4. Identify in writing specific contract requirements that are not approved or warrantable by manufacturer.

B. Do not deliver to site or install material or system that has not been approved. Remove materials installed without prior approval upon the Owner's or Owner's Representative's request.

C. Restrict traffic on completed roof areas. Coordinate work to prevent trafficking by working toward roof edges and access ways. Should access to completed roof areas be necessary, provide protection for trafficked areas.

D. Roofing Inspections: Cooperate and coordinate with inspectors, testing agencies and manufacturers, in order to facilitate inspection and installation, to include allowance of field sampling. Field sampling will only be performed if moisture intrusion is suspected.

E. Fire-Test-Response Characteristics: Provide membrane roofing materials with fire-test-response characteristics indicated as determined by testing identical products per test method below by UL, FMG, or another testing and inspecting agency acceptable to authorities having jurisdiction.

1. Exterior Fire-Test Exposure: Class A; ASTM E 108, for application and roof slopes indicated.

F. Source Limitations: Obtain components for membrane roofing system and other specified roofing products from same manufacturer as membrane roofing or approved by membrane roofing manufacturer.

1.4 GUARANTEES AND WARRANTIES

A. Provide complete roof system to be covered by roof membrane manufacturer’s system warranty. Provide materials not included in Specifications where required by manufacturer to obtain requested warranty, without additional charge to the Owner.

B. Roof membrane manufacturer’s system warranty meeting following minimum criteria:

1. Coverage to repair damage to system components resulting from leaks due to failure of materials or workmanship.
2. Non-prorated, non-penal sum (no dollar limit), 20-year warranty period.
3. No exclusion from coverage for damage to roof system from wind gusts less than 55 miles per hour.

C. Contractor’s Guarantee: Submit a full Contractor's Guarantee of the Work to be free from defect in materials and workmanship upon Substantial Completion, and prior to final payment. This Guarantee shall be for a period of five (5) years from the date of Substantial Completion and shall be signed by a Principal of the Contractor’s firm and sealed if a corporation.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Source Limitations: All liquid applied PMMA membrane and accessories shall be manufactured by a single supplier or approved for use by the membrane manufacturer. All PMMA materials used for flashings (Base Bid) shall be supplied by or approved by the modified bitumen membrane manufacturer.

B. Manufacturers: Subject to compliance with requirements, provided products by one of the following:

1. SOPREMA, Inc.; Alsan RS System
2. Siplast, Inc; Parapro 123 System
3. Johns Manville; Seamfree PMMA Liquid Membrane.

2.2 PERFORMANCE REQUIREMENTS

A. General Performance: Installed membrane roofing and base flashings shall withstand specified uplift pressures, thermally induced movement, and exposure to weather without failure due to defective manufacture, fabrication, installation, or other defects in construction. Membrane roofing and base flashings shall remain watertight.

B. Material Compatibility: Provide roofing materials that are compatible with one another under conditions of service and application required, as demonstrated by membrane roofing manufacturer based on testing and field experience.

C. FM Approvals Listing: Provide membrane roofing, base flashings, and component materials that comply with requirements in FM Approvals 4450 and FM Approvals 4470 as part of a membrane roofing system, and that are listed in FM Approvals' "RoofNav" for Class 1 or noncombustible construction, as applicable. Identify materials with FM Approvals markings.

1. Fire/Windstorm Classification: Class 1A-90.
2. Hail Resistance: MH.

D. Provide roof edge and perimeter sheet metal components complying with ANSI/SPRI ES1 and acceptable to manufacturer for inclusion into roof system.

2.3 UNDERLAYMENT/TEMPORARY MEMBRANE (1-PLY SBS MODIFIED BITUMEN MEMBRANE)

A. Field and Flashings: ASTM D6164, modified bitumen membrane with sanded surface and self-adhering backing, suitable for heat-welded seams.

2.4 LIQUID APPLIED WATERPROOFING SYSTEM

A. Flashing Membrane:

1. Polymethyl Methacrylate Flashing Membrane (PMMA):

a. Rapid curing, polymethyl methacrylate (PMMA) liquid resin with an embedded polyester reinforcement fabric used for monolithic waterproofing flashing membranes.

i. VOC content: 4.2 g/L
ii. Color: White.

B. Field Membrane:

1. Polymethyl Methacrylate Membrane (PMMA):

a. Rapid curing, polymethyl methacrylate (PMMA) liquid resin with an embedded polyester reinforcement fabric used for monolithic waterproofing field membranes.

i. VOC content: 2.3 g/L (summer), 2.4 g/L (winter).
ii. Color: White.
iii. Elongation at peak load, avg. (ASTM D412): 55%.
iv. Peak load at 73°F, avg. (ASTM D412): 809 lbf/in^2.
v. Tear strength (ASTM D 5147): 107 lbf.
vi. Shore A hardness, avg. (ASTM D2240): 81
vii. Water absorption (Method I, 24h@73°F) (ASTM D570): 0.41%.
viii. Water absorption (Method I, 48h@122°F)(ASTM D570): 1.57%.
ix. Low temperature flexibility (ASTM D5147): -13°F.
x. Dimensional stability (ASTM D5147): -0.063%.

2.5 ACCESSORIES

A. Primers:

1. Rapid curing, polymethyl methacrylate (PMMA) liquid resin used to promote adhesion of PMMA membranes over wood, concrete and approved waterproofing substrates.
2. Rapid curing, polymethyl methacrylate (PMMA) liquid resin used to promote adhesion of PMMA membranes over non-SBS, asphaltic substrates.
3. Low odor, two-part, epoxy based primer for concrete and approved substrates.
4. Solvent-based primer used to improve the adhesion of PMMA membranes to metal substrates.

B. Catalyst:

1. Reactive agent used to cure PMMA liquid resins.

C. Reinforcing Fabric:

1. Woven polyester reinforcement used in PMMA liquid applied membrane and flashing applications.

a. Thickness: 30-40 mils (0.8-1 mm)
b. Weights: 110 g/m^2

D. Cleaner:

1. Clear, blended solvent used to clean and prepare plastic and metal surfaces, and used to clean existing ALSAN RS surfaces prior to the application of PMMA liquid applied membrane and flashings.

a. VOC content: 900 g/L
b. Color: Clear

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examination includes visual observations, qualitative analysis, and quantitative testing measures as necessary to ensure conditions are satisfactory to begin and remain satisfactory throughout the project.

B. The contractor shall examine all waterproofing substrates including, but not limited to: decks, walls, curbs, equipment, fixtures, and wood blocking.

C. The applicator shall not begin installation until conditions have been properly examined and determined to be clean, dry and, otherwise satisfactory to receive specified roofing and waterproofing materials.

3.2 PREPARATION

A. Before commencing work each day the contractor shall prepare all substrates to ensure conditions are satisfactory to proceed with the installation of specified materials.

B. Preparation of substrates includes, but is not limited to, the following:

1. General:

a. All substrates must be clean, dry and free from gross irregularities, loose, unsound or foreign material such as dirt, ice, snow, water, grease, oil, release agents, lacquers, or any other condition that would be detrimental to adhesion of primer and/or resin materials to the substrate. Most surfaces will require mechanical abrasion in the form of scarifying, shot-blasting or grinding to achieve a suitable substrate.
b. Inspect all substrates and correct defects before application of waterproofing materials. Fill all surface voids 1/16 in (1.5 mm) or greater wide and/or deep with appropriate fill material.

C. Where conditions are found to be unsatisfactory, work shall not begin until conditions are adjusted appropriately. Commencing of work shall indicate contractor’s acceptance of conditions.

D. Underlayment/Temporary Membrane Installation

1. Field of Roof Installation

a. Ensure that substrate is clean and dry.
b. Remove the silicone release film and adhere to the substrate.
c. Heat weld all seams.

2. Base Flashing Installation

    a. Prepare and prime substrate.
    b. Remove the silicone release film and adhere to the substrate.
    c. Heat weld all seams.

3.3 PRIMER APPLICATION (GENERAL)

A. Refer to manufacturer's detail drawings, product data sheets and published general requirements for application rates and specific installation instructions.

B. Examine all substrates and conduct adhesion peel tests as necessary to ensure satisfactory adhesion is achieved.

3.4 PMMA PRIMER APPLICATION

A. Mix primer resin and catalyst approximately 2 minutes using a clean spiral agitator on slow speed or stir stick until evenly mixed. Do not aerate. Mix only the amount of primer that can be used within the application time.

B. Apply the appropriate specified primer to dry, compatible substrates as required to enhance adhesion of new specified waterproofing materials.

C. Apply primer using brush or roller at the rate published on the product data sheet. Do not allow primer to pond or collect in low areas.

D. Project conditions vary throughout the day. Monitor changing conditions, and the curing time of primers.

E. Allow primer to fully cure before membrane application.

3.5 METAL PRIMER APPLICATION

A. Mix primer resin approximately 2 minutes using a clean spiral agitator on slow speed or stir stick until evenly mixed. Do not aerate. Mix only the amount of primer that can be used within the application time.

B. Apply the appropriate specified primer to dry, compatible substrates as required to enhance adhesion of new specified waterproofing materials.

C. Apply primer using brush or roller at the rate published on the product data sheet. Do not allow primer to pond or collect in low areas.

D. Project conditions vary throughout the day. Monitor changing conditions, and the curing time of primers.

E. Allow primer to fully cure before membrane application.

3.6 FLASHING MEMBRANE APPLICATION

A. General:

1. Provide a minimum vertical height of 8 in (20 cm) for all flashing terminations wherever possible.
2. All flashing shall be terminated as shown on the Drawings.
3. The primed substrate shall be dry and free of any dust, loose particles or contaminants.
4. Precut reinforcing fleece to conform to terminations, transitions and penetrations being flashed. Ensure a minimum 2 in (5 cm) overlap of fleece at side laps and extend flashing 4 in (10 cm) minimum horizontally onto deck unless otherwise specified. Ensure the completed liquid applied flashing membrane is fully reinforced.
5. Mix waterproofing resin and catalyst approximately 2 minutes using a clean spiral agitator on slow speed or stir stick until evenly mixed. Do not aerate. Mix only the amount of waterproofing resin that can be used within the application time.
6. Apply the base coat of catalyzed waterproofing resin onto the substrate using a brush or roller, working the material into the surface for complete coverage and full adhesion.
7. Immediately apply the reinforcing fleece into the wet base coat of resin making sure the smooth side is up. Using a brush or roller, work the reinforcing fabric into the wet resin while applying the second coat of catalyzed waterproofing resin to completely encapsulate the fleece. Avoid any folds and wrinkles.
8. At membrane tie-ins, clean cured membrane with specified cleaner before application of adjacent membrane.

B. Penetrations:

1. Pipes, Conduits, Posts, Supports and Unusual Shaped Penetrations:

   a. Pipes, conduits and other items to be flashed must be separated with ½ in (1.3 cm) minimum clearance or as recommended by manufacturer to adequate waterproof each individual penetration.
   b. All penetrations must be flashed individually. Two or more items ganged together in a flashing will NOT be permitted.
   c. Flash penetrations using cold liquid applied reinforced membrane or proprietary fibrated flashing resin as recommended. Flashing shall consist of a reinforced deck skirt/target flashing applied over a reinforced vertical wrap finger flashing.

2. Walls, Curbs and Bases:

   a. Flash all walls, curbs and bases using cold liquid applied reinforced membrane. Wherever possible extend flashing up and over tops of walls, curbs and bases so the membrane terminates on the opposite face of the vertical element.

3. Non-standard Flashing Details:

   a. When required, consult manufacturer for recommendations on flashing non-standard conditions, penetrations or protrusions.

3.7 FIELD MEMBRANE APPLICATION

A. Refer to manufacturer's detail drawings, product data sheets and published general requirements for application rates and specific installation instructions.

B. Install all flashing membranes before installing field membranes (Alternate No. 1 only).

C. The primed substrate shall be dry and free of any dust, loose particles or contaminants.

D. Precut reinforcing fleece to conform to terminations, transitions and penetrations being flashed. Ensure a minimum 2 in (5 cm) overlap of fleece at side and 4 in (10 cm) at end-laps. Ensure the completed liquid applied membrane is fully reinforced.

E. Mix waterproofing resin and catalyst approximately 2 minutes using a clean spiral agitator on slow speed or stir stick until evenly mixed. Do not aerate. Mix only the amount of product that can be used within the application time.

F. Apply the base coat of catalyzed waterproofing resin onto the substrate using a brush or roller, working the material into the surface for complete coverage and full adhesion.

G. Immediately apply the reinforcing fleece into the wet base coat of waterproofing resin making sure the smooth side is up. Using a brush or roller, work the reinforcing fabric into the wet resin while applying the second coat of catalyzed waterproofing resin to completely encapsulate the fleece. Avoid any folds and wrinkles.

H. At membrane tie-ins, clean cured membrane with specified cleaner before application of adjacent membrane.

3.10 CLEAN UP

A. Uncured resin is considered a hazardous material. Unused resin must be catalyzed and cured prior to disposal.

B. Clean up and properly dispose of waste and debris resulting from these operations each day as required to prevent damages and disruptions to operations.

3.11 PROTECTION

A. Upon completion of new work (including all associated work), institute appropriate procedures for surveillance and protection of finished work during remainder of construction period. Protect all areas where waterproofing membrane has been installed.

END OF SECTION 075600

SECTION 076000 - FLASHING AND SHEET METAL

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide perimeter and penetration sheet metal flashings and components at locations indicated on the drawings and as required to properly terminate the roof system.

1.2 SUBMITTALS

A. Product Data:

1. For each item specified in Part 2 of this Section.
2. Color charts for coated metals.

B. Shop Drawings: Show layouts, profiles, shapes, seams, dimensions, and details for fastening, joining, supporting, and anchoring sheet metal flashing and trim.

C. Certifications: Perimeter sheet metal assembly must be in compliance with IBC requirements, specifically ANSI/SPRI ES-1 protocol.

1.3 QUALITY ASSURANCE

A. Installation procedures shall be in accordance with the industry standards and codes indicated in this Section.

B. Sheet Metal Flashing and Trim Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" unless more stringent requirements are specified or shown on Drawings.

C. Sheet Metal Standard: Comply with NRCA “Roofing and Waterproofing Manual, Fifth Edition.” Conform to dimensions and profiles shown unless more stringent requirements are indicated.

D. Mockups: Build mockups to demonstrate aesthetic effects and set quality standards for fabrication and installation. Include seams, attachments, underlayment, and accessories.

1. Parapet Cap
2. Gutter

1.4 WARRANTY

A. Special Warranty on Finishes: Manufacturer's standard form in which manufacturer agrees to repair finish or replace sheet metal flashing and trim that shows evidence of deterioration of factory-applied finishes within 20 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SHEET METALS

A. Aluminum Sheet: ASTM B 209, Alloy 3004, temper not less than H14; provide with manufacturer’s strippable plastic film. Required finish:

1. High-Performance Organic Finish: Thermocured system containing not less than 70 percent polyvinylidene fluoride (Kynar/Hylar) resin by weight; complying with AAMA 2604; color as selected by Owner from standard colors.

B. Stainless-Steel Sheet: ASTM A 240, Type 304, No. 2D finish.

C. Lead Sheet: ASTM B 749, Type L51121, copper-bearing lead sheet.

2.2 ACCESSORIES

A. General: Provide materials and types of fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required for complete sheet metal flashing and trim installation.

B. Self-Adhering Membrane: High temperature self-adhering, SBS modified bitumen membrane with poly-surface and release-paper backing, minimum 40-mil thickness, designed for a minimum melting temperature of 220 deg F such as Ice & Water Shield HT by W.R. Grace, Lastobond Shield HT by Soprema, Metshield by MetFab, or accepted substitute.

C. Sealant Tape: Pressure-sensitive, 100 percent solids, polyisobutylene compound sealing tape with release-paper backing. Provide permanently elastic, nonsag, nontoxic, nonstaining tape.

D. Exposed elastomeric Sealant: ASTM C 920, Type S, Grade NS, Class 25, Use A. Use an elastomeric polyurethane polymer sealant.

E. Concealed sealant for metal-to-metal connections: ASTM C 1311, single-component, butyl (polyisobutylene) rubber sealant, heavy bodied for hooked-type expansion joints with limited movement.

F. Pourable Sealer Pocket Filler

1. Two-part polyurethane pourable sealer for sealing roof penetrations: manufactured or approved by roof system manufacturer.

2. Gypsum concrete: Mill-mixed; ASTM C 317, Class A, with minimum compressive strength of 500 psi; Pyrofil, as manufactured by U.S. Gypsum/Poteet Industries, or accepted substitute.

G. Band Clamps: Stainless steel, including screw-adjustable clamps; 1/2-inch wide.

H. Flux: muriatic acid based with zinc.

I. Solder: ASTM B 32, 50% block tin and 50% pig lead; manufactured for use with stainless steel or copper.

J. Splash Block: Precast concrete formed to divert water in one direction. Splash block shall be in smooth forms with bottom edges rounded or chamfered to prevent abrasion.

K. Cold Applied Adhesive: See Division 07 Section “Modified Bituminous Membrane Roofing.”

L. Termination Bar: Manufacturer's standard, predrilled aluminum bars, approximately 1 by 1/8-inch thick with sealant edge. Holes shall be predrilled at 6-inches on center.

M. EPDM Membrane: 0.045-inches thick, non-reinforced EPDM, white.

2.3 FASTENERS

A. Sheet metal to wood blocking connections (concealed securement): No. 12 annular threaded Series 300 stainless steel nails minimum 1-1/2-inches long.

B. Sheet metal to wood blocking connections and mechanical unit securement (exposed securement): Self-drilling, self-tapping, Number 10, stainless steel hex-washer-head screws, 1-1/2-inch long, with metal-capped EPDM washers.

C. Sheet metal to masonry wall connections: 1/4-inch diameter, concrete/masonry screws of sufficient length to penetrate substrate 1-1/2-inch minimum. Provide metal capped EPDM washers at exposed locations.

D. Fasteners for downspout to downspout outlet connections: #10 Series 300 stainless steel screws, 1/2-inch long or stainless steel pop rivets.

E. Nuts and bolts for gutter assembly: Series 300 stainless steel, #12-24, 1-inch to 1-1/2-inch long.

F. Gutter Spacers: 3-inches long, #12, Type 304, Series 300 stainless steel screws or #14 fluorocarbon coated screws.

2.4 FABRICATION – GENERAL

A. General: Fabricate sheet metal flashing and trim to comply with IBC and recommendations in SMACNA and NRCA that apply to design, dimensions, metal, and other characteristics of item indicated. Obtain field measurements for accurate fit before shop fabrication.

B. Fabricate sheet metal flashing and trim without excessive oil canning, buckling, and tool marks and true to line and levels indicated, with exposed edges folded back to form hems.

1. Seams for Aluminum: Fabricate nonmoving seams with flat-lock seams. Form seams and seal with epoxy seam sealer. Rivet joints for additional strength.
2. Seams for Other Than Aluminum: Fabricate nonmoving seams in accessories with flat-lock seams. Tin edges to be seamed, form seams, and solder.

C. Sealed Joints: Form nonexpansion but movable joints in metal to accommodate elastomeric sealant to comply with SMACNA recommendations.

D. Expansion Provisions: Where lapped expansion provisions in Work cannot be used, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

E. Provide concealed fasteners and expansion provisions where possible on exposed-to-view sheet metal flashing and trim, unless otherwise indicated.

F. Provide cleats and attachment devices from same material as accessory being anchored or from compatible, noncorrosive metal, and in thickness not less than that of metal being secured.

2.5 FABRICATION SCHEDULE

A. PVDF Coated Aluminum (.040-inch)

1. Parapet Caps
2. Closures
3. Counterflashing at Parapet and Columns
4. Gutter
5. Downspout Outlet
6. Securement Clips
7. Conductor Head
8. Scupper Face Plate

B. Aluminum (.050-inch)

1. Cleats
2. Deflector at N.I.C. Metal Roof

C. Stainless Steel (26 gauge)

1. Reglet Counterflashing
2. Counterflashing
3. Clips (Counterflashing, Skirt Flashing)
4. Pourable Sealer Boxes
5. Storm Hoods and Sleeves
6. Scupper Sleeve
7. Door Threshold Cover
8. Curb Cover

D. Stainless Steel (1-inch by 1/8-inch bar)

1. Gutter Spacer
2. Gutter Reinforcing Bar

E. Stainless Steel (Expanded metal- 26 gauge minimum with 3/8-inch diameter holes)

1. Gutter Guard

PART 3 - EXECUTION

3.1 PREPARATION

A. Verify that substrate and anchorage materials to receive sheet metal flashings are properly secured and aligned, without gaps, lumps, or offsets that may distort metal.

B. Install underlayment at roof edges, parapets, curbs, and similar transitions, and as shown on Drawings.

3.2 INSTALLATION, GENERAL

A. Comply with these specifications and applicable industry standards to include the IBC, NRCA, and SMACNA, whichever is more stringent.

B. General: Anchor sheet metal flashing and trim and other components of Work securely in place, with provisions for thermal and structural movement. Use fasteners, solder, welding rods, protective coatings, separators, sealants, and other miscellaneous items as required to complete sheet metal flashing and trim system.

1. Torch cutting of sheet metal flashing and trim is not permitted.

C. Metal Protection: Where dissimilar metals will contact each other or corrosive substrates, protect against galvanic action by painting contact surfaces with bituminous coating or by other permanent separation as recommended by fabricator or manufacturers of dissimilar metals.

D. Install exposed sheet metal flashing and trim without excessive oil canning, buckling, and tool marks.

E. Install sheet metal flashing and trim true to line and levels indicated. Provide uniform, neat seams with minimum exposure of solder, welds, and butyl sealant.

F. Install sheet metal flashing and trim to fit substrates and to result in watertight performance. Verify shapes and dimensions of surfaces to be covered before fabricating sheet metal.

G. Expansion Provisions: Provide for thermal expansion of exposed flashing and trim. Space movement joints at maximum of 10-feet, with no joints allowed within 18-inches of corner or intersection. Where lapped expansion provisions cannot be used or would not be sufficiently

watertight, form expansion joints of intermeshing hooked flanges, not less than 1-inch deep, filled with butyl sealant concealed within joints.

H. Fasteners: Use fasteners of sizes that will penetrate substrate not less than 1-1/4-inches for nails and not less than 3/4-inch for wood screws.

I. Non-moving seams and joints on non-solderable metal shall be interlocked, filled with sealant, and riveted, unless otherwise indicated.

J. Seal joints as required for watertight construction. Use elastomeric sealant for exposed conditions. Use butyl sealant for hidden conditions.

K. Provide sheet metal closure components at transitions to rising walls and similar changes in plane for edge metal, parapet caps, expansion joint covers, and other termination flashings. Fully crimp and seal closures to continuous blind nailed cleats.

L. Soldered Joints: Comply with SMACNA and CDA requirements. Use conduction soldering methods.

1. Clean surfaces to be soldered, removing oils and foreign matter. Smooth irregularities and round edges. Pretin edges of sheets to be soldered to width of 1-1/2-inches except where pretinned surface would show in finished Work.
2. Apply flux to surfaces to receive solder. Remove oxides and other impurities from joint.
3. Position and immobilize parts to be soldered. Heat parts above fluid temperature of solder. Draw solder into joint, creating 1-inch wide lap. Allow to cool before moving parts.
4. Remove flux and acid by cleaning with neutralizing agent.

M. Fabricate sheet metal components to the dimensions and shapes shown on the Drawings.

3.3 METAL COMPONENT INSTALLATION

A. Securement Clips

1. Securement clips shall be 6-inches long and 2-inches wide.
2. Secure clips to substrate with specified fasteners. Space clips 12-inches on center.
3. Bend clips minimum of 1-inch over bottom drip edge of counterflashing and crimp loosely.

B. Cleats

1. Form cleats with 3/4-inch kicks, bent out at maximum angle of 45 degrees to the vertical surface. Height of cleat shall be 3-3/4-inches unless otherwise indicated on Drawings.
2. Secure continuous cleats to wood blocking with fasteners spaced at 6-inches on center.
3. Provide 1/4-inch gap between cleat sections. Offset from joints in cover metal being secured.

C. Sheet Metal Transition Closures

1. Extend sheet metal 4-inches minimum vertically up wall at sheet metal-to-wall transitions.

2. Set sheet metal in full bed of butyl mastic and secure using appropriate screws with EPDM washers spaced at 4-inches along centerline of vertical portions.
3. Fold vertical portion down over fasteners. Provide bead of sealant along sheet metal at wall.

D. Parapet Caps

1. Provide self-adhering membrane over parapet.
2. Fabricate parapet cap to dimensions and shapes shown on Drawings and to fit snugly over parapet and membrane flashings.
3. Secure continuous cleat at interior and exterior face or crimp the interior face onto existing parapet cap as shown on Drawings.
4. Provide 6-inch wide backer plates at section joints. Provide continuous concealed sealant bead on either side of joint.

E. Closure at Parapet Cap

1. Fabricate closure to fit snug under existing parapet cap.
2. Turn down over liquid-applied flashing minimum 4-inches.
3. Fasten on vertical face at 6-inches on center with specified fasteners.

F. Reglet Counterflashing

1. Saw cut reglet into brick masonry mortar joints to depth of 1-1/2-inches and width of 3/8-inch. Clean loose particles from reglet and fill reglet with butyl sealant.
2. Form horizontal flange of counterflashing with “V” bend up at 45 degree angle and not less than 3/4-inch long. Provide bend with spring action within reglet.
3. Insert counterflashing into reglet and secure with lead wedges spaced at 8-inches on center. Provide minimum of 3 wedges per length of counterflashing. Ensure that counterflashing and wedges are driven in sufficiently to provide sealant coverage. Install sealant above exterior edge of counterflashing.

G. Counterflashing

1. At locations indicated, secure counterflashing in existing receiver. Provide securement clips at 12-inches on center.
2. Surface-Mounted Counterflashing:
   a. Set vertical face of counterflashing in continuous butyl sealant. Fasten to substrate at 12-inches on center.
   b. Provide continuous bead of elastomeric sealant at top edge of counterflashing.

H. Sheet Metal Hoods

1. Fabricate and install sheet metal hoods on conduit pipe, and vent penetrations to cover membrane flashings. Clamp tops of sleeves prior to installing hoods. Set hoods in bed of sealant and clamp to penetration.

I. Skirt Flashing

1. Insert skirt flashing beneath existing and new equipment covers. Lap skirt flashing sections 3-inches minimum.
2. Secure skirt flashing with sheet metal clips spaced 12-inches on center and minimum of 2 per side of curb.

J. Counterflashing at Columns

1. Provide counterflashing bent at 90 degree angle to cover cavity behind existing metal wall panels.
2. Fasten to existing panels at 6-inches on center, minimum 3 fasteners per side of column. Ensure fasteners penetrate existing subgirts at each corner
3. Provide continuous sealant at transition to steel tube column.

K. Scupper/Conductor Head

1. Provide scupper with locked and folded seams. Insert scupper sleeve into opening and secure interior flanges to wood blocking with specified fasteners at 3-inches on center.
2. Install sheet metal scupper sleeve prior to parapet cap installation. Scupper sleeve flanges shall be secured to previously installed wood blocking and extend up wall as indicated in Drawings.
3. Secure conductor head to wood blocking with specified fasteners spaced at 3-inches on center.
4. Secure existing downspout to new conductor box.

L. Gutter and Outlets

1. Slope gutters to drain. Drip edge fascias shall provide minimum 2-1/2-inch lap over back of gutter box. Provide sealant-filled 3-inch-wide section laps. Provide 2 rows of pop rivets spaced 4-inches on center along gutter section laps and at downspouts. Provide 6-inch wide, fully adhered, EPDM membrane over section joints. Provide expansion joints at high points of gutter.
2. Secure continuous stiffening bar and gutter spacers to outer edge of gutter box with bolt and nut connections. Space spacers at 24-inches on center. Secure spacers into wood blocking with fasteners, 1 screw per spacer.
3. Extend horizontal flange of downspout outlet 1-inch onto floor of gutter box. Set outlet in sealant and pop rivet, 4 per outlet. Extend outlet down vertically 4-inches, for downspout securement. Secure to existing downspout.
4. Terminate gutter +/- 3-inches prior to parapet walls. Remove existing snow guards and provide sheet metal deflector to direct water to gutter.
5. Provide splash blocks below each downspout at roof level set on walkway pad.
6. Install gutter guard in 4-foot long sections in gutter as shown on drawings. Notch gutter guard around spacers. Gutter guard should have a spring-type fit but able to be removed without tools..

M. Multi-Pipe Penetration Curb

1. Provide tapered edge strip, cant, or chamfered wood blocking as required to create smooth transitions at existing curb cover seams.

2. Provide fully adhered EPDM membrane over existing curb cover. Flash pipe penetrations and pourable sealer pockets in accordance with manufacturer's requirements.
3. Turn EPDM membrane down onto vertical face of existing curb cover and terminate with continuous termination bar.

N. Pourable Sealer Pockets

1. Provide pourable sealer pockets only where field fabricated pipe flashings cannot be installed.
2. Fabricate pourable sealer boxes 6-inches high, with minimum 2-inch wide clear space on each side around each penetration.
3. Prime flanges and set in bed of adhesive.
4. Secure deck flanges to substrate as specified.
5. Pour premixed gypsum concrete into box to depth 2-inches from top and allow to set.
6. Fill remaining 2-inches with pourable sealer to top of box and allow to set. Tool pourable sealer to shed water.
7. Provide sheet metal storm hood set in sealant and secured with band clamp as indicated on Drawings.
8. Flash flanges in accordance with membrane requirements and Drawings.

3.4 CLEANING

A. Remove scrap metal, burrs, fasteners, and related debris from roof daily. Take precautions to prevent damage to roof membrane and flashings.

END OF SECTION 076000

SECTION 077200 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide roof accessory components as indicated on the Drawings.

1.2 SUBMITTALS

A. Product Data: For each type of roof accessory indicated.

B. Shop Drawings: Show fabrication and installation details for roof accessories.

C. Manufacturer Installation Instructions: For each product in Part 2.

1.3 QUALITY ASSURANCE

A. Comply with manufacturer’s recommendations and requirements.

B. Verify locations, dimensions, and substrate conditions before installation.

PART 2 - PRODUCTS

2.1 CONDUIT/PIPE/DUCT SUPPORTS

A. Conduit/Pipe/Duct Support:

1. Telescoping 12 gauge, galvanized steel unistrut frame, 1-5/8-inch by 1-7/8-inch, with 18-inch by 18-inch, high-density polypropylene bases and stainless steel hardware.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General

1. Coordinate installation of roof accessories with installation of roof insulation, flashing, roofing membranes, penetrations, equipment, and other construction to ensure that combined elements are weatherproof and watertight.
2. Install roof accessory items according to construction details in NRCA's "Roofing and

Waterproofing Manual," unless otherwise indicated,

3. Separation: Separate metal from incompatible metal or corrosive substrates, including wood, by coating concealed surfaces, at locations of contact, with bituminous coating or providing other permanent separation.

B. Conduit, Pipe, and Duct Supports

1. Place protection layer on completed roof membrane to extend beyond base minimum 3-inches in each direction.
2. Set supports to provide stable base for conduits, duct, or pipes. Adjust as necessary. Accurately locate and align.
3. Provide supports at 4-feet on center.
4. Secure conduit, duct, or pipes to supports.

3.2 REINSTALLATION

A. Reinstall equipment disturbed or disconnected by work of this section. Extend and reconnect electrical and mechanical connections. Restore normal operation of equipment.

3.3 CLEANING

A. Clean exposed surfaces according to manufacturer's written instructions. Touch up damaged metal coatings.

END OF SECTION 077200

SECTION 079200 – JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide sealant and backer materials at exterior vertical joints as indicated on the Drawings.
2. Provide sealant materials at all joints in reinstalled metal wall panels.

1.2 SUBMITTALS

A. Product Data: All items specified in Part 2 of this Section.

1.3 QUALITY ASSURANCE

A. Utilize skilled and experienced specialty workers to install work. Experienced trade workers shall be utilized for each aspect of work.

B. Preconstruction Field-Adhesion Testing: Before installing elastomeric sealants, field test their adhesion to Project joint substrates according to the method in ASTM C 1193 that is appropriate for the types of Project joints.

1.4 WARRANTY

A. Special Manufacturer's Warranty: Manufacturer's standard form in which elastomeric sealant manufacturer agrees to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SEALANTS

A. Color(s) shall be selected by Owner from approved manufacturer's color chart. Colors shall be manufacturers available premium colors such as "Fast Pak" by Tremco or approved equal. Owner may require a minimum of two (2) sealant colors to be installed at each new sealant joint type. Contractor will include multiple colors in his/her Bid.

B. Sealant for exposed masonry joints/wall panels: single component urethane such as Dymonic by Tremco, Dynatrol I by Pecora, or NP-1 by Sonneborne conforming to ASTM C 920, Type S, Grade NS, Class 25, Use M and A.

C. Sealant for concealed joints shall be one-part butyl sealant, conforming to ASTM C 1311.

2.2 ACCESSORIES

A. Primer shall be non-staining type as manufactured or recommended by sealant manufacturer for each substrate.

B. Joint cleaner shall be non-corrosive and non-staining as recommended by sealant manufacturer. Cleaner shall be totally compatible with sealant for each substrate.

C. Bond breaker tape shall be pressure-sensitive tape as recommended by sealant manufacturer.

D. Backer rod shall be continuous length, closed-cell polyethylene foam, as recommended by sealant manufacturer. Backer rod shall be compressible, resilient, non-waxing, non-extruding, and non-staining. Backer rod shall be of sufficient size to be compressed 30% of maximum joint width and shall be totally compatible with sealant, primer, and substrates. Backers shall conform to requirements of ASTM C 1330, ASTM D 1622, ASTM D 1623, and ASTM D 5249.

E. Masking material shall be commercially available masking tape of appropriate width or other material recommended by sealant manufacturer. Self-adhesive masking materials shall be of low tack and completely strippable, leaving no adhesive residue behind when removed.

PART 3 - EXECUTION

3.1 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants.

1. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant.

    a. Clean porous joint substrate surfaces by brushing, grinding, blast cleaning, 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.

B. Joint Priming: Prime joint substrates, where recommended in writing by joint-sealant manufacturer, based on 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 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 – GENERAL

A. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

B. Install sealant backings 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. Provide a 2:1 width to depth ratio unless otherwise indicated by the manufacturer.

1. Do not leave gaps between ends of sealant backings.
2. Do not stretch, twist, puncture, or tear sealant backings.
3. Provide approximately 30% compression of backer materials.

C. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.

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 according to requirements specified 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 configuration per Figure 8A in ASTM C 1193, unless otherwise indicated.

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.

END OF SECTION 079200

SECTION 099653 - ELASTOMERIC COATINGS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide coating on newly installed modified bitumen roof system (Base Bid).

1.2 PERFORMANCE REQUIREMENTS

A. Provide elastomeric coating systems with the following properties as determined by test methods indicated:

1. Elongation: Not less than 100 percent with a tensile strength of 1.3 MPA and not less than 88 percent recovery after 1 hour and 90 percent recovery after 24 hours when tested according to ASTM D 2370 using parameters established by MPI 113.
2. Accelerated Weathering: No cracking, peeling, blistering, chalking, or visual deterioration after 1000 hours when tested according to procedures in ASTM G 155.
3. Low-Temperature Flexibility: No crack formation when tested according to ASTM D 1737.
4. Wind-Driven Rain Resistance: No water penetration according to procedures in FS TT-C-555.

1.3 SUBMITTALS

A. Product Data: For each elastomeric coating system specified. Include crack fillers, block fillers, and primers.

1. Material List: An inclusive list of required coating materials. Indicate each material and cross-reference the specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.
2. Manufacturer's Information: Technical information including label analysis and instructions for handling, storing, and applying each coating material.

B. Qualification Data: For Applicator.

C. Material Certificates: For each elastomeric coating material, signed by manufacturers.

D. Product Test Reports: Based on evaluation of comprehensive tests by a qualified testing agency for each elastomeric coating material indicating compliance of elastomeric coatings with requirements based on comprehensive testing within the last two years of current product formulations.

1.4 QUALITY ASSURANCE

A. Applicator Qualifications: A firm or individual experienced in applying elastomeric coating systems similar in material and extent to those indicated for this Project, whose work has resulted in applications with a record of successful in-service performance.

B. Source Limitations: Obtain crack fillers and other undercoat materials from same manufacturer as finish coats.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label.

B. Store materials not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 7 deg C (45 deg F). Maintain storage containers in a clean condition, free of foreign materials and residue.

1.6 WARRANTY

A. Elastomeric Coating Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace elastomeric coatings that fail within specified warranty period. Failures include, but are not limited to, water penetration through the coating.

B. Warranty Period for Elastomeric Coatings: Two years from date of Substantial Completion.

1.7 EXTRA MATERIALS

A. Furnish extra elastomeric coating materials from same production run as materials applied and in quantities described below. Package materials in unopened, factory-sealed containers for storage and identify with labels describing contents. Deliver extra materials to Contracting Officer's Representative.

1. Quantity: Furnish Contracting Officer's Representative with 2 gal. of elastomeric coating materials applied.

PART 2 - PRODUCTS

2.1 ELASTOMERIC COATING MATERIALS, GENERAL

A. Material Compatibility: Provide crack fillers, block fillers, primers, elastomeric finish-coat materials, and related materials 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.

B. Material Quality: Provide manufacturer's best-quality elastomeric coating materials that are factory formulated, comply with requirements in FS TT-C-555, and are recommended by manufacturer for the application indicated. Material containers not displaying manufacturer's product identification are not acceptable.

1. Proprietary Names: Use of manufacturer's proprietary product names to designate colors or materials is not intended to imply that products named are required to be used to the exclusion of equivalent products of other manufacturers. Furnish manufacturer's material data and certificates of performance of proposed substitutions.

C. Colors and Textures: Manufacturer's standard smooth texture. Color shall be white.

2.2 CRACK FILLERS

A. Crack Fillers: Factory-formulated acrylic emulsion crack fillers compatible with substrate and finish-coat materials indicated.

2.3 PRIMERS

A. Factory-formulated, alkali-resistant, acrylic-latex primer as recommended by coating manufacturer.

2.4 ELASTOMERIC FINISH-COAT MATERIALS

A. Smooth Elastomeric Finish: Smooth, factory-formulated, 100 percent acrylic elastomeric coating with a minimum of 50% solids by volume and a minimum SRI of 80 such as Eterna-Seal 8101 by Truco, Inc. or RCS 5000 by Lapollo Industries, Inc.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Applicator present, for compliance with requirements for coating application. Comply with procedures specified in PDCA P4.

1. Proceed with coating application only after unsatisfactory conditions have been corrected and surfaces are thoroughly dry.
2. Start of coating application will be construed as Applicator's acceptance of surface conditions.
3. Provide minimum 30-day “flash-off” period, or as required by manufacturer, for the cold-applied modified bitumen roof assembly.

B. Coordination of Work: Review other Sections in which primers are provided to ensure compatibility of total system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

3.2 PREPARATION

A. General: Remove hardware and hardware accessories, plates, machined surfaces, light fixtures, and similar items already installed that are not to be coated. If removal is impractical or impossible because of size or weight of item, provide surface-applied protection before surface preparation and coating.

1. After completing coating operations, reinstall items removed, using workers skilled in trades involved.

B. Cleaning: Before applying coatings or other surface treatments, clean substrates of substances that could impair bond of coating systems. Remove oil and grease before cleaning.

1. Schedule cleaning and coating application so dust and other contaminants from cleaning process will not fall on wet, newly coated surfaces.

C. Surface Preparation: Clean and prepare surfaces to be coated according to manufacturer's written instructions for particular substrate conditions and as specified.

1. Provide barrier coats over incompatible primers or remove and reprime.

D. Minimum Coating Thickness: Apply each material no thinner than manufacturer's recommended spreading rate. Provide total dry film thickness as recommended by manufacturer but in no case less than .012-inch.

E. Prime Coats: If recommended by manufacturer, apply a primer to material being coated before applying finish coats.

F. Brush Application: Brush out and work brush coats into surfaces in an even film. Eliminate cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections. Neatly draw glass lines and color breaks.

G. Roller Application: Keep cover wet at all times; do not dry roll. Work in sections. Lay on required amount of material, working material into grooves and rough areas; then level material, working it into surface.

H. Completed Work: Match approved samples for color, texture, and coverage. Remove, refinish, or recoat work not complying with specified requirements.

3.3 CLEANING

A. Cleanup: At end of each workday, remove rubbish, empty cans, rags, and other discarded materials from Project site.

3.4 PROTECTION

A. Protect work of other trades from damage whether being coated or not. Correct damage by cleaning, repairing, replacing, and recoating as approved by Owner's Representative. Leave in an undamaged condition.

B. Provide "Wet Paint" signs to protect newly coated finishes. Remove temporary protective wrappings provided by others to protect their work after completing coating operations.

1. After construction activities of other trades are complete, touch up and restore damaged or defaced coated surfaces. Comply with procedures specified in PDCA P1.

3.5 COATING SCHEDULE

A. Provide elastomeric coating systems according to the following schedule:

1. All Surfaces:

a. Primer: 1 coat if required by the coating manufacturer.
b. Finish Coats: 2 coats.

END OF SECTION 099653

SECTION 221426.13 – ROOF DRAINS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section specifies requirements for the following Scope of Work:

1. Provide drain bowls, strainers, clamping rings, underdeck clamps, and pipe joint connections at all existing roof drain locations.
2. Clear roof drain systems from roof level to the point where the leaders exit the building to achieve a free-flowing system.

1.2 SUBMITTALS

A. Product Data: For each type of product indicated.

1.3 PROJECT CONDITIONS

A. Sections of the existing interior finish ceiling systems will require removal. These areas should be reviewed with Owner prior to removal. Work areas shall be clearly defined and closed-off from building occupants. Areas of ceiling removal shall be as small as possible to effectively install the work. Any adjacent ceilings damaged during installation shall be repaired or replaced by the Contractor at no cost to the Owner.

B. Existing roof drain outlet diameters vary. Contractor shall confirm conditions prior to ordering materials.

C. The plumbing work shall be coordinated with roof work in such a manner that drain bowl assemblies are installed concurrently with the roofing and that no interior portions of the building are left exposed to the elements at the end of a day's work. Install replacement drain bowl assemblies before new roofing is in place.

D. The Contractor shall provide all rooftop protection for new and existing roofs.

E. All plumbing work shall be performed by a licensed plumber in accordance with the International Plumbing Code (IPC).

F. The Contractor shall investigate the ceiling conditions. PVC piping shall not be used if the ceiling is used as a return air plenum.

PART 2 - PRODUCTS

2.1 ROOF DRAIN COMPONENTS

A. Roof drain: Coated cast iron with bottom outlets, large-sump style, with wide roof flanges, such as “Series 21500” manufactured by Josam Company or approved equal. Outlet diameters shall match the existing leader pipe diameters.

B. Drain strainers: Coated cast iron of suitable size and configuration to be installed on the new drain bowl assemblies.

C. Clamping rings: Non-puncturing type, with integral gravel stops, either coated cast iron or stainless steel, sized to match the drain bowls. Bolts, nuts, and washers required for securement of clamping rings to drain bowls shall be stainless steel.

D. Underdeck clamps: Coated cast iron, provided by the drain bowl manufacturer for application beneath roof decks.

2.2 ACCESSORIES

A. Leader pipe: Schedule 40 PVC pipe. Pipe and connections shall be sized to tie into existing leader piping.

B. Drain bowl to leader pipe connections: 4 band, no hub, neoprene connections.

C. Pipe Connections: Solvent welded connections.

D. Hangers and fittings: Conforming to Manufacturer’s Standardization Society of Valve and Fittings Industry (MCC) SP-58 and SP-59 guidelines. Hangers and strapping material shall be of approved material that will not promote galvanic reaction. Cast iron fittings shall conform to the American Society of Mechanical Engineers (ASME) B16.4 and B16.12.

E. Steel plate for drain bowl locations shall be minimum 24 gauge hot dipped galvanized plate as provided by the drain bowl manufacturer. Plate shall be a minimum size of 16-inches by 16-inches with central hole of suitable size to receive new drain bowl.

F. Insulation for drain bowls and leader piping: Fibrous glass batt type with premolded PVC jackets. Insulation shall be minimum 1-inch thick.

PART 3 - EXECUTION

3.1 PREPARATION

A. The Owner shall be notified at least 72 hours prior to all underdeck work. All materials, equipment and daily clean-up shall be the responsibility of the Contractor.

B. All flashing-in of the roof drains and membrane repairs as a result of the plumbing work shall be the responsibility of and provided for by the Contractor.

C. The Contractor is cautioned to investigate all existing conditions and materials of construction. All replacement items must be completely compatible with and match the existing system.

D. Comply with Division 1 GENERAL REQUIREMENTS for preparation, protection and clean-up of interior and exterior work areas.

3.2 CEILING REMOVAL

A. Do not remove any ceiling areas without the prior approval of the Owner and Owner's Representative. The limits of ceiling removal to facilitate installation of the new plumbing work shall be clearly defined. All precautions shall be taken to protect the building interior and occupants during ceiling removal and replacement.

B. Do not damage or cut any of the ceiling support system without the Owner's and Owner's Representative's approval. Should the support system be damaged or removed to facilitate plumbing work installation, it shall be replaced with a new support system equal to the existing, at no additional cost to the Owner.

C. All floor and adjacent areas, both interior and exterior, damaged or stained by the installation of the plumbing work shall be cleaned of all dust, debris and any other materials to the Owner's satisfaction.

3.3 DRAIN BOWL ASSEMBLY INSTALLATION

A. Install new roof drains such that the bowl flange with clamping ring and integral gravel stop are level (see Detail Drawings for assembly position).

B. Provide manufacturer supplied, prefabricated, galvanized steel plate over opening. Mechanically attach plate to steel deck with specified fasteners, 2 per side.

C. Make drain to leader connections watertight and of proper strength using no hub connections.

D. Install drain bowl insulation and PVC jackets. Join sections with tape or other methods indicated by the manufacturer. Extend insulation to the first elbow or 2-feet.

E. Drain components shall be completed and flashed in the same day's operation.

F. Check all drain joints with a water test once the roofing and flashing are completed.

3.4 CLEANING OF DRAINAGE SYSTEM

A. Once the new roof system has been installed, clear all roof drain leader piping and underground leaders of debris and clogs such that the system is free-flowing.

B. The Contractor shall clear the existing leader pipe with rooter-type equipment from the roof deck level to the point where the drain pipes exit the building.

3.5 WATER TESTS

A. Perform water tests on roof drain assemblies, including leader piping, and on gutter assemblies and scuppers. Using 3/4-inch garden hose, run water into the drainage components for thirty minutes. Inspect all drainage components for leakage and repair as required. Inform Owner of test findings.

END OF SECTION 221426.13

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

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

1.3 COORDINATION

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

PART 2 - PRODUCTS

2.1 GENERAL MOTOR REQUIREMENTS

A. Comply with NEMA MG 1 unless otherwise indicated.

2.2 MOTOR CHARACTERISTICS

A. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet above sea level.

B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

C. All motors shall be provided with Aegis shaft grounding brushes.

D. All motors used in conjunction with variable frequency drives shall be inverter duty type.

2.3 POLYPHASE MOTORS

A. Description: NEMA MG 1, Design B, medium induction motor.

B. Efficiency: Energy efficient, as defined in NEMA MG 1.

C. Multispeed Motors: Variable torque.
1. For motors with 2:1 speed ratio, consequent pole, single winding.
2. For motors with other than 2:1 speed ratio, separate winding for each speed.

D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.

E. Temperature Rise: Match insulation rating.

F. Insulation: Class F.

G. Code Letter Designation:
1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.

H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.4 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

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

2.5 SINGLE-PHASE MOTORS

A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
1. Permanent-split capacitor.
2. Split phase.
3. Capacitor start, inductor run.
4. Capacitor start, capacitor run.

B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

C. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.

D. Motors 1/20 HP and Smaller: Shaded-pole type.

E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 230513

SECTION 230514 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. BMS: Building management system.

B. IGBT: Integrated gate bipolar transistor.

C. LAN: Local area network.

D. PID: Control action, proportional plus integral plus derivative.

E. PWM: Pulse-width modulated.

F. VFC: Variable frequency controller.

1.4 SUBMITTALS

A. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.

B. Shop Drawings: For each VFC.
   a. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
   b. Nameplate legends.
   c. Short-circuit current rating of integrated unit.
   d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
   e. Features, characteristics, ratings, and factory settings of each motor-control center unit.
   2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.

C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are

prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

D. Manufacturer Seismic Qualification Certification: Submit certification that VFCs, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
      a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
      b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Qualification Data: For manufacturer and testing agency.

F. Field quality-control test reports.

G. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
   1. Routine maintenance requirements for VFCs and all installed components.
   2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

I. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.

B. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
   1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.

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

E. Comply with NFPA 70.

F. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, minimum clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.7 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions, unless otherwise indicated:
1. Ambient Temperature: 0 to 40 deg C.
2. Humidity: Less than 90 percent (noncondensing).
3. Altitude: Not exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items. Comply with indicated maximum dimensions.

1.8 COORDINATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.

E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
   1. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
   2. Indicating Lights: Two of each type installed.

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. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary ACH400
   2. Danfoss VLT 6000
   3. Toshiba international Corp. Q9
   4. Yaskawa America Inc. E7

2.2 VARIABLE FREQUENCY CONTROLLERS

A. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
   1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.

B. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

C. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.

D. Unit Operating Requirements:
   1. Input ac voltage tolerance of 380 to 500 V, plus or minus 10 percent.
   2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
   3. Minimum Efficiency: 96 percent at 60 Hz, full load.
   4. Minimum Displacement Primary-Side Power Factor: 96 percent.
   5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
   6. Starting Torque: 100 percent of rated torque or as indicated.
   7. Speed Regulation: Plus or minus 1 percent.

E. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.

1. Electrical Signal: 4 to 20 mA at 24 V.
2. Pneumatic Signal: 3 to 15 psig (20 to 104 kPa).

F. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to a minimum of 22 seconds.
4. Deceleration: 2 to a minimum of 22 seconds.
5. Current Limit: 50 to a minimum of 110 percent of maximum rating.

G. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors.
2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 20 performance.
4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
5. Instantaneous line-to-line and line-to-ground overcurrent trips.
6. Loss-of-phase protection.
7. Reverse-phase protection.
8. Short-circuit protection.
9. Motor overtemperature fault.

H. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.

I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.

J. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

K. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

L. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

M. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.

N. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).

6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

O. Control Signal Interface:
1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
   e. RS485.
   f. Keypad display for local hand operation.
4. Output Signal Interface:
   a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
      1) Output frequency (Hz).
      2) Output current (load).
      3) DC-link voltage (VDC).
      4) Motor torque (percent).
      5) Motor speed (rpm).
      6) Set-point frequency (Hz).
5. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set-point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

P. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.

Q. Manual Bypass: Magnetic contactor arranged to safely transfer motor between controller output and bypass controller circuit when motor is at zero speed. Controller-off-bypass selector switch sets mode, and indicator lights give indication of mode selected. Unit shall be capable of stable operation (starting, stopping, and running), with motor completely disconnected from controller (no load).

R. Bypass Controller: NEMA ICS 2, full-voltage, nonreversing enclosed controller with across-the-line starting capability in manual-bypass mode. Provide motor overload protection under both modes of operation with control logic that allows common start-stop capability in either mode.

S. Integral Disconnecting Means: NEMA AB 1, molded-case switch with lockable handle.

T. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

U. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.

2.3 ACCESSORIES

A. Devices shall be factory installed in controller enclosure, unless otherwise indicated. Enclosure shall be suitable for exterior rooftop locations, minimum NEMA 4X.

B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.

C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:
1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

G. Current-Sensing, Phase-Failure Relays for Bypass Controller: Solid-state sensing circuit with isolated output contacts for hard-wired connection; arranged to operate on phase failure, phase reversal, current unbalance of from 30 to 40 percent, or loss of supply voltage; with adjustable response delay.

H. All controllers shall be provided with anti-condensation heating strips with internal thermostat

I. As controllers shall be provided with internal cooling fans with internal thermostat.

2.4 FACTORY FINISHES

A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested VFCs before shipping.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

B. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.2 APPLICATIONS

A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.

B. Select horsepower rating of controllers to suit motor controlled.

3.3 INSTALLATION

A. Anchor each VFC assembly to steel-channel sills arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface. All VFC’s shall be AHU mounted. Coordinated with AHU manufacturer shall be completed prior to AHU being purchased.

B. All Air handling units shall be provided with unit mounted variable frequency controllers (VFC). Coordinated quantity of VFCDs with unit manufacturer. Contractor to coordinated field measurements of existing to remain items on roof to ensure new unit mounted VFCs have required clearances.

C. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers and Supports for Electrical Systems."

D. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.4 IDENTIFICATION

A. Identify VFCs, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.5 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
   1. Connect selector switches to bypass only manual- and automatic-control devices that have no safety functions when switch is in hand position.
   2. Connect selector switches with control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.6 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

3.7 FIELD QUALITY CONTROL

A. Prepare for acceptance tests as follows:
1. Test insulation resistance for each enclosed controller element, bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Assist in field testing of equipment including pretesting and adjusting of solid-state controllers.
3. Report results in writing.

C. Testing Agency: Owner will engage a qualified testing and inspecting agency to perform field tests and inspections and prepare test reports.

D. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:

E. Perform the following field tests and inspections and prepare test reports:
1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.8 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 DEMONSTRATION

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

END OF SECTION 230514

SECTION 230519 - METERS AND GAGES FOR HVAC 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. Filled-system thermometers.
2. Liquid-in-glass thermometers.
3. Thermowells.
4. Dial-type pressure gages.
5. Gage attachments.
6. Test plugs.
7. Pitot-tube flowmeters.
8. Turbine flowmeters.
9. Venturi flowmeters.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of meter and gage, from manufacturer.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For meters and gages to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 FILLED-SYSTEM THERMOMETERS

A. Direct-Mounted, Metal-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

a. Ashcroft Inc.
b. Marsh Bellofram.
c. Miljoco Corporation.
d. Palmer Wahl Instrumentation Group.
e. REOTEMP Instrument Corporation.
f. Trerice, H. O. Co.
g. Weiss Instruments, Inc.

3. Standard: ASME B40.200.
4. Case: Sealed type, cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
5. Element: Bourdon tube or other type of pressure element.
6. Movement: Mechanical, dampening type, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Metal.
11. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
12. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
13. Accuracy: Plus or minus 1 percent of scale range.

B. Direct-Mounted, Plastic-Case, Vapor-Actuated Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
    a. Ashcroft Inc.
    b. Miljoco Corporation.
    c. REOTEMP Instrument Corporation.
3. Standard: ASME B40.200.
4. Case: Sealed type, plastic; 4-1/2-inch nominal diameter.
5. Element: Bourdon tube or other type of pressure element.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
8. Pointer: Dark-colored metal.
9. Window: plastic.
10. Ring: plastic.
11. Connector Type(s): Union joint, adjustable, 180 degrees in vertical plane, 360 degrees in horizontal plane, with locking device; with ASME B1.1 screw threads.
12. Thermal System: Liquid-filled bulb in copper-plated steel, aluminum, or brass stem and of length to suit installation.
    a. Design for Air-Duct Installation: With ventilated shroud.
    b. Design for Thermowell Installation: Bare stem.
13. Accuracy: Plus or minus 1 percent of scale range.

2.2 LIQUID-IN-GLASS THERMOMETERS

A. Metal-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Trerice, H. O. Co.
3. Standard: ASME B40.200.
4. Case: Cast aluminum; 6-inch nominal size.
5. Case Form: Straight unless otherwise indicated.
6. Tube: Glass with magnifying lens and blue organic liquid.
7. Tube Background: Nonreflective aluminum with permanently etched scale markings graduated in deg F and deg C.
8. Window: Glass or plastic.
9. Stem: Aluminum or brass and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
10. Connector: 3/4 inch, with ASME B1.1 screw threads.
11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

B. Plastic-Case, Compact-Style, Liquid-in-Glass Thermometers:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Flo Fab Inc.
   b. Miljoco Corporation.
   c. Tel-Tru Manufacturing Company.
   d. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   e. Weiss Instruments, Inc.
   f. WIKA Instrument Corporation - USA.
3. Standard: ASME B40.200.
4. Case: Plastic; 6-inch nominal size.
5. Case Form: Straight unless otherwise indicated.
6. Tube: Glass with magnifying lens and blue organic liquid.
7. Tube Background: Nonreflective with permanently etched scale markings graduated in deg F and deg C.
8. Window: Glass or plastic.
9. Stem: Aluminum or brass and of length to suit installation.
   a. Design for Air-Duct Installation: With ventilated shroud.
   b. Design for Thermowell Installation: Bare stem.
10. Connector: 3/4 inch, with ASME B1.1 screw threads.
11. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.3 DUCT-THERMOMETER MOUNTING BRACKETS

A. Description: Flanged bracket with screw holes, for attachment to air duct and made to hold thermometer stem.

2.4 THERMOWELLS

A. Thermowells:
1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR.
4. Material for Use with Steel Piping: CRES.

5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.5 PRESSURE GAGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Ernst Flow Industries.
   d. Flo Fab Inc.
   e. Marsh Bellofram.
   f. Miljoco Corporation.
   g. Noshok.
   h. Palmer Wahl Instrumentation Group.
   i. REOTEMP Instrument Corporation.
   j. Tel-Tru Manufacturing Company.
   k. Trerice, H. O. Co.
   l. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
   m. Weiss Instruments, Inc.
   n. WIKA Instrument Corporation - USA.
   o. Winters Instruments - U.S.
3. Standard: ASME B40.100.
4. Case: Liquid-filled type(s); cast aluminum or drawn steel; 4-1/2-inch nominal diameter.
5. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
6. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2 NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
9. Pointer: Dark-colored metal.
10. Window: Glass.
11. Ring: Brass.
12. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

B. Direct-Mounted, Plastic-Case, Dial-Type Pressure Gages:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. AMETEK, Inc.; U.S. Gauge.
   b. Ashcroft Inc.
   c. Flo Fab Inc.
   d. Marsh Bellofram.

e. Miljoco Corporation.
f. Noshok.
g. Palmer Wahl Instrumentation Group.
h. REOTEMP Instrument Corporation.
i. Tel-Tru Manufacturing Company.
j. Trerice, H. O. Co.
k. Weiss Instruments, Inc.
l. WIKA Instrument Corporation - USA.
m. Winters Instruments - U.S.

3. Standard: ASME B40.100.
4. Case: Sealed type; plastic; 4-1/2-inch nominal diameter.
5. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
6. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
7. Movement: Mechanical, with link to pressure element and connection to pointer.
8. Dial: Nonreflective aluminum with permanently etched scale markings graduated in psi and kPa.
9. Pointer: Dark-colored metal.
10. Window: Glass.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.6 GAGE ATTACHMENTS

A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.

B. Siphons: Loop-shaped section of stainless-steel pipe with NPS 1/4 or NPS 1/2 pipe threads.

C. Valves: Brass or stainless-steel needle, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.7 TEST PLUGS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

C. Description: Test-station fitting made for insertion into piping tee fitting.

D. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

E. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

F. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

G. Core Inserts: EPDM self-sealing rubber.

2.8 TEST-PLUG KITS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Flow Design, Inc.
2. Miljoco Corporation.
3. National Meter, Inc.
4. Peterson Equipment Co., Inc.
5. Sisco Manufacturing Company, Inc.
6. Trerice, H. O. Co.
7. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
8. Weiss Instruments, Inc.

C. Furnish one test-plug kit(s) containing one thermometer(s), one pressure gage and adapter, and carrying case. Thermometer sensing elements, pressure gage, and adapter probes shall be of diameter to fit test plugs and of length to project into piping.

D. Low-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 25 to 125 deg F.

E. High-Range Thermometer: Small, bimetallic insertion type with 1- to 2-inch- diameter dial and tapered-end sensing element. Dial range shall be at least 0 to 220 deg F.

F. Pressure Gage: Small, Bourdon-tube insertion type with 2- to 3-inch- diameter dial and probe. Dial range shall be at least 0 to 200 psig.

G. Carrying Case: Metal or plastic, with formed instrument padding.

2.9 FLOWMETERS

A. Pitot-Tube Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. ABB; Instrumentation and Analytical.
   b. Emerson Process Management; Rosemount.
   c. Meriam Process Technologies.
   d. Preso Meters; a division of Racine Federated Inc.
   e. TACO Incorporated.
   f. Veris Industries, Inc.
3. Description: Flowmeter with sensor and indicator.
4. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
5. Sensor: Insertion type; for inserting probe into piping and measuring flow directly in gallons per minute.

a. Design: Differential-pressure-type measurement for oil.
b. Construction: Stainless-steel probe of length to span inside of pipe, with integral transmitter and direct-reading scale.
c. Minimum Pressure Rating: 150 psig.
d. Minimum Temperature Rating: 250 deg F.

6. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
7. Integral Transformer: For low-voltage power connection.
8. Accuracy: Plus or minus 3 percent.
9. Display: Shows rate of flow, with register to indicate total volume in gallons.
10. Operating Instructions: Include complete instructions with each flowmeter.

B. Turbine Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. ABB; Instrumentation and Analytical.
b. Data Industrial Corp.
c. EMCO Flow Systems; a division of Spirax Sarco, Inc.
d. ERDCO Engineering Corp.
e. Hoffer Flow Controls, Inc.
f. Liquid Controls; a unit of IDEX Corporation.
g. McCrometer, Inc.
h. Midwest Instruments & Controls Corp.
i. ONICON Incorporated.
j. SeaMetrics, Inc.
k. Sponsler, Inc.; a unit of IDEX Corporation.
3. Description: Flowmeter with sensor and indicator.
4. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
5. Sensor: Impeller turbine; for inserting into pipe fitting or for installing in piping and measuring flow directly in gallons per minute.
a. Design: Device or pipe fitting with inline turbine and integral direct-reading scale for oil.
b. Construction: Bronze or stainless-steel body, with plastic turbine or impeller.
c. Minimum Pressure Rating: 150 psig.
d. Minimum Temperature Rating: 180 deg F.
6. Indicator: Hand-held meter; either an integral part of sensor or a separate meter.
7. Accuracy: Plus or minus 1-1/2 percent.
8. Display: Shows rate of flow, with register to indicate total volume in gallons.
9. Operating Instructions: Include complete instructions with each flowmeter.

C. Venturi Flowmeters:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. ABB; Instrumentation and Analytical.
b. Gerand Engineering Co.
c. Hyspan Precision Products, Inc.
d. Preso Meters; a division of Racine Federated Inc.
e. S. A. Armstrong Limited; Armstrong Pumps Inc.
f. Victaulic Company.
3. Description: Flowmeter with calibrated flow-measuring element, hoses or tubing, fittings, valves, indicator, and conversion chart.

4. Flow Range: Sensor and indicator shall cover operating range of equipment or system served.
5. Sensor: Venturi-type, calibrated, flow-measuring element; for installation in piping.
   a. Design: Differential-pressure-type measurement for oil.
   b. Construction: Bronze, brass, or factory-primed steel, with brass fittings and attached tag with flow conversion data.
   c. Minimum Pressure Rating: 250 psig.
   d. Minimum Temperature Rating: 250 deg F.
   e. End Connections for NPS 2 and Smaller: Threaded.
   f. End Connections for NPS 2-1/2 and Larger: Flanged or welded.
   g. Flow Range: Flow-measuring element and flowmeter shall cover operating range of equipment or system served.
6. Permanent Indicators: Meter suitable for wall or bracket mounting, calibrated for connected flowmeter element, and having 6-inch- diameter, or equivalent, dial with fittings and copper tubing for connecting to flowmeter element.
   a. Scale: Gallons per minute.
   b. Accuracy: Plus or minus 1 percent between 20 and 80 percent of scale range.
7. Display: Shows rate of flow, with register to indicate total volume in gallons.
8. Conversion Chart: Flow rate data compatible with sensor.
9. Operating Instructions: Include complete instructions with each flowmeter.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install thermowells with socket extending one-third of pipe diameter and in vertical position in piping tees.

B. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.

C. Install thermowells with extension on insulated piping.

D. Fill thermowells with heat-transfer medium.

E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.

F. Install remote-mounted thermometer bulbs in thermowells and install cases on panels; connect cases with tubing and support tubing to prevent kinks. Use minimum tubing length.

G. Install duct-thermometer mounting brackets in walls of ducts. Attach to duct with screws.

H. Install direct-mounted pressure gages in piping tees with pressure gage located on pipe at the most readable position.

I. Install remote-mounted pressure gages on panel.

J. Install valve and snubber in piping for each pressure gage for fluids (except steam).

K. Install valve and syphon fitting in piping for each pressure gage for steam.

L. Install test plugs in piping tees.

M. Install flow indicators in piping systems in accessible positions for easy viewing.

N. Assemble and install connections, tubing, and accessories between flow-measuring elements and flowmeters according to manufacturer's written instructions.

O. Install flowmeter elements in accessible positions in piping systems.

P. Install wafer-orifice flowmeter elements between pipe flanges.

Q. Install differential-pressure-type flowmeter elements, with at least minimum straight lengths of pipe, upstream and downstream from element according to manufacturer's written instructions.

R. Install permanent indicators on walls or brackets in accessible and readable positions.

S. Install connection fittings in accessible locations for attachment to portable indicators.

T. Mount thermal-energy meters on wall if accessible; if not, provide brackets to support meters.

U. Install thermometers in the following locations:
1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Two inlets and two outlets of each chiller.
4. Inlet and outlet of each hydronic coil in air-handling units.
5. Two inlets and two outlets of each hydronic heat exchanger.
6. Inlet and outlet of each thermal-storage tank.
7. Outside-, return-, supply-, and mixed-air ducts.

V. Install pressure gages in the following locations:
1. Discharge of each pressure-reducing valve.
2. Inlet and outlet of each chiller chilled-water and condenser-water connection.
3. Suction and discharge of each pump.

3.2 CONNECTIONS

A. Install meters and gages adjacent to machines and equipment to allow service and maintenance of meters, gages, machines, and equipment.

B. Connect flowmeter-system elements to meters.

C. Connect flowmeter transmitters to meters.

D. Connect thermal-energy meter transmitters to meters.

3.3 ADJUSTING

A. After installation, calibrate meters according to manufacturer's written instructions.

B. Adjust faces of meters and gages to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers at inlet and outlet of each hydronic zone shall be one of the following:

1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

B. Thermometers at inlets and outlets of each chiller shall be one of the following:
1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

C. Thermometers at inlet and outlet of each hydronic coil in air-handling units and built-up central systems shall be one of the following:
1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

D. Thermometers at inlet and outlet of each hydronic heat-recovery unit shall be one of the following:
1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

E. Thermometers at inlet and outlet of each thermal-storage tank shall be one of the following:
1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.
5. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

F. Thermometers at outside-, return-, supply-, and mixed-air ducts shall be one of the following:
1. Liquid-filled, bimetallic-actuated type.
2. Direct-mounted, metal-case, vapor-actuated type.
3. Compact-style, liquid-in-glass type.
4. Direct-mounted, light-activated type.

G. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 100 deg F 0 to 100 deg F and minus 20 to plus 50 deg C.

B. Scale Range for Heating, Hot-Water Piping: 20 to 240 deg F 20 to 240 deg F and 0 to 150 deg C.

C. Scale Range for Air Ducts: 0 to 150 deg F 0 to 150 deg F and minus 20 to plus 70 deg C.

3.6 PRESSURE-GAGE SCHEDULE

A. Pressure gages at discharge of each pressure-reducing valve shall be one of the following:
1. Sealed, direct-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

B. Pressure gages at inlet and outlet of each chiller chilled-water and condenser-water connection shall be one of the following:
1. Sealed, direct remote-mounted, metal case.
2. Sealed, direct-mounted, plastic case.
3. Test plug with chlorosulfonated polyethylene synthetic self-sealing rubber inserts.

3.7 PRESSURE-GAGE SCALE-RANGE SCHEDULE

A. Scale Range for Chilled-Water Piping: 0 to 200 psi 0 to 200 psi and 0 to 1400 kPa.

B. Scale Range for Chilled-Water Piping: 0 to 600 psi 0 to 600 psi and 0 to 4000 kPa.

3.8 FLOWMETER SCHEDULE

A. Flowmeters for Chilled-Water Piping: Turbine type.

B. Flowmeters for Heating, Hot-Water Piping: Turbine type.

END OF SECTION 230519

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC 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. Bronze angle valves.
2. Brass ball valves.
3. Iron ball valves.
4. High-performance butterfly valves.
5. Iron swing check valves with closure control.
6. Bronze gate valves.
7. Bronze globe valves.
8. Lubricated plug valves.
9. Eccentric plug valves.

B. Related Sections:
1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.3 DEFINITIONS

A. CWP: Cold working pressure.

B. EPDM: Ethylene propylene copolymer rubber.

C. NBR: Acrylonitrile-butadiene, Buna-N, or nitrile rubber.

D. NRS: Nonrising stem.

E. OS&Y: Outside screw and yoke.

F. RS: Rising stem.

G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of valve indicated.

1.5 QUALITY ASSURANCE

A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.

B. ASME Compliance:
1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
2. ASME B31.1 for power piping valves.
3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Prepare valves for shipping as follows:
1. Protect internal parts against rust and corrosion.
2. Protect threads, flange faces, grooves, and weld ends.
3. Set angle, gate, and globe valves closed to prevent rattling.
4. Set ball and plug valves open to minimize exposure of functional surfaces.
5. Set butterfly valves closed or slightly open.
6. Block check valves in either closed or open position.

B. Use the following precautions during storage:
1. Maintain valve end protection.
2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.

C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

A. Refer to HVAC valve schedule articles for applications of valves.

B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

C. Valve Sizes: Same as upstream piping unless otherwise indicated.

D. Valve Actuator Types:
1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
2. Handwheel: For valves other than quarter-turn types.
3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 10 Insert number plug valves, for each size square plug-valve head.
5. 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.

E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
1. Gate Valves: With rising stem.

2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:
1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.2 BRONZE ANGLE VALVES

A. Class 125, Bronze Angle Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Hammond Valve.
   b. Milwaukee Valve Company.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

B. Class 125, Bronze Angle Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. American Valve, Inc.
   b. NIBCO INC.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 150, Bronze Angle Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.

f. Packing: Asbestos free.
g. Handwheel: Malleable iron.

D. Class 150, Bronze Angle Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. NIBCO INC.
2. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: PTFE or TFE.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.3 BRASS BALL VALVES

A. Two-Piece, Full-Port, Brass Ball Valves with Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Jenkins Valves.
c. Flow-Tek, Inc.; a subsidiary of Bray International, Inc.
d. Jamesbury; a subsidiary of Metso Automation.
e. Kitz Corporation.
f. NIBCO INC.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Two piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

B. Three-Piece, Full-Port, Brass Ball Valves with Brass Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Jomar International, LTD.
b. Kitz Corporation.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.

h. Stem: Brass.
i. Ball: Chrome-plated brass.
j. Port: Full.

C. Three-Piece, Full-Port, Brass Ball Valves with Stainless-Steel Trim:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Jomar International, LTD.
b. Kitz Corporation.
c. Marwin Valve; a division of Richards Industries.
2. Description:
a. Standard: MSS SP-110.
b. SWP Rating: 150 psig.
c. CWP Rating: 600 psig.
d. Body Design: Three piece.
e. Body Material: Forged brass.
f. Ends: Threaded.
g. Seats: PTFE or TFE.
h. Stem: Stainless steel.
i. Ball: Stainless steel, vented.
j. Port: Full.

2.4 IRON BALL VALVES

A. Class 125, Iron Ball Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Conbraco Industries, Inc.; Apollo Valves.
b. Kitz Corporation.
c. Sure Flow Equipment Inc.
2. Description:
a. Standard: MSS SP-72.
b. CWP Rating: 200 psig.
c. Body Design: Split body.
d. Body Material: ASTM A 126, gray iron.
e. Ends: Flanged.
f. Seats: PTFE or TFE.
g. Stem: Stainless steel.
h. Ball: Stainless steel.
i. Port: Full.

2.5 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Bray Controls; a division of Bray International.
b. Crane Co.; Crane Valve Group; Flowseal.
c. Crane Co.; Crane Valve Group; Stockham Division.
d. DeZurik Water Controls.
e. Jamesbury; a subsidiary of Metso Automation.
f. NIBCO INC.
g. Process Development & Control, Inc.
h. Tyco Valves & Controls; a unit of Tyco Flow Control.

i. Xomox Corporation.

2. Description:
   a. Standard: MSS SP-68.
   b. CWP Rating: 285 psig at 100 deg F.
   c. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
   d. Body Material: Carbon steel, cast iron, ductile iron, or stainless steel.
   e. Seat: Reinforced PTFE or metal.
   f. Stem: Stainless steel; offset from seat plane.
   g. Disc: Carbon steel.
   h. Service: Bidirectional.

B. Class 300, Single-Flange, High-Performance Butterfly Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Bray Controls; a division of Bray International.
   b. Crane Co.; Crane Valve Group; Flowseal.
   c. DeZurik Water Controls.
   d. Jamesbury; a subsidiary of Metso Automation.
   e. NIBCO INC.
   f. Tyco Valves & Controls; a unit of Tyco Flow Control.
   g. Xomox Corporation.

2.6 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever- and Spring-Closure Control:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. NIBCO INC.
2. Description:
   a. Standard: MSS SP-71, Type I.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
   c. NPS 14 to NPS 24, CWP Rating: 150 psig.
   d. Body Design: Clear or full waterway.
   e. Body Material: ASTM A 126, gray iron with bolted bonnet.
   f. Ends: Flanged.
   g. Trim: Bronze.
   h. Gasket: Asbestos free.
   i. Closure Control: Factory-installed, exterior lever and spring.

2.7 BRONZE GATE VALVES

A. Class 125, NRS Bronze Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Jenkins Valves.
   b. Kitz Corporation.
   c. NIBCO INC.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.

e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

B. Class 125, RS Bronze Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Jenkins Valves.
b. Kitz Corporation.
c. NIBCO INC.
d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
e. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 200 psig.
c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

C. Class 150, NRS Bronze Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Hammond Valve.
b. Kitz Corporation.
c. NIBCO INC.
2. Description:
a. Standard: MSS SP-80, Type 1.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron, bronze, or aluminum.

D. Class 150, RS Bronze Gate Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
a. Crane Co.; Crane Valve Group; Crane Valves.
b. Crane Co.; Crane Valve Group; Stockham Division.
c. Kitz Corporation.
d. NIBCO INC.
e. Zy-Tech Global Industries, Inc.
2. Description:
a. Standard: MSS SP-80, Type 2.
b. CWP Rating: 300 psig.
c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
d. Ends: Threaded.
e. Stem: Bronze.
f. Disc: Solid wedge; bronze.
g. Packing: Asbestos free.
h. Handwheel: Malleable iron.

2.8 BRONZE GLOBE VALVES

A. Class 125, Bronze Globe Valves with Bronze Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Stockham Division.
   b. Kitz Corporation.
   c. NIBCO INC.
   d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
   e. Zy-Tech Global Industries, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 1.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem and Disc: Bronze.
   f. Packing: Asbestos free.
   g. Handwheel: Malleable iron.

B. Class 125, Bronze Globe Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Crane Co.; Crane Valve Group; Stockham Division.
   c. NIBCO INC.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 200 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

C. Class 150, Bronze Globe Valves with Nonmetallic Disc:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Crane Co.; Crane Valve Group; Crane Valves.
   b. Hammond Valve.
   c. Kitz Corporation.
   d. NIBCO INC.
   e. Zy-Tech Global Industries, Inc.
2. Description:
   a. Standard: MSS SP-80, Type 2.
   b. CWP Rating: 300 psig.
   c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
   d. Ends: Threaded.
   e. Stem: Bronze.
   f. Disc: PTFE or TFE.
   g. Packing: Asbestos free.
   h. Handwheel: Malleable iron.

2.9 LUBRICATED PLUG VALVES

A. Class 125, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Nordstrom Valves, Inc.
   2. Description:
      a. Standard: MSS SP-78, Type II.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      e. Pattern: Regular.
      f. Plug: Cast iron or bronze with sealant groove.

B. Class 125, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Nordstrom Valves, Inc.
   2. Description:
      a. Standard: MSS SP-78, Type II.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      e. Pattern: Regular.
      f. Plug: Cast iron or bronze with sealant groove.

C. Class 125, Cylindrical, Lubricated Plug Valves with Threaded Ends:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Homestead Valve; a division of Olson Technologies, Inc.
      b. Milliken Valve Company.
      c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
   2. Description:
      a. Standard: MSS SP-78, Type IV.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      e. Pattern: Regular.
      f. Plug: Cast iron or bronze with sealant groove.

D. Class 125, Cylindrical, Lubricated Plug Valves with Flanged Ends:
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Homestead Valve; a division of Olson Technologies, Inc.
      b. Milliken Valve Company.
      c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
   2. Description:
      a. Standard: MSS SP-78, Type IV.
      b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
      c. NPS 14 to NPS 24, CWP Rating: 150 psig.
      d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
      e. Pattern: Regular.

f. Plug: Cast iron or bronze with sealant groove.

E. Class 250, Regular-Gland, Lubricated Plug Valves with Threaded Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Nordstrom Valves, Inc.
2. Description:
   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular.
   f. Plug: Cast iron or bronze with sealant groove.

F. Class 250, Regular-Gland, Lubricated Plug Valves with Flanged Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Nordstrom Valves, Inc.
2. Description:
   a. Standard: MSS SP-78, Type II.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular.
   f. Plug: Cast iron or bronze with sealant groove.

G. Class 250, Cylindrical, Lubricated Plug Valves with Threaded Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems; a unit of Robbins & Myers, Inc.
2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, cast iron with lubrication-sealing system.
   e. Pattern: Regular.
   f. Plug: Cast iron or bronze with sealant groove.

H. Class 250, Cylindrical, Lubricated Plug Valves with Flanged Ends:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. Homestead Valve; a division of Olson Technologies, Inc.
   b. Milliken Valve Company.
   c. R & M Energy Systems, a unit of Robbins & Myers, Inc.
2. Description:
   a. Standard: MSS SP-78, Type IV.
   b. NPS 2-1/2 to NPS 12, CWP Rating: 400 psig.
   c. NPS 14 to NPS 24, CWP Rating: 300 psig.
   d. Body Material: ASTM A 48/A 48M or ASTM A 126, Grade 40 cast iron with lubrication-sealing system.
   e. Pattern: Regular.

f. Plug: Cast iron or bronze with sealant groove.

2.10 ECCENTRIC PLUG VALVES

A. 175 CWP, Eccentric Plug Valves with Resilient Seating.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   a. DeZurik Water Controls.
   b. M&H Valve Company; a division of McWane, Inc.
   c. Henry Pratt Company.
2. Description:
   a. Standard: MSS SP-108.
   b. CWP Rating: 175 psig minimum.
   c. Body and Plug: ASTM A 48/A 48M, gray iron; ASTM A 126, gray iron; or ASTM A 536, ductile iron.
   d. Bearings: Oil-impregnated bronze or stainless steel.
   e. Ends: Flanged.
   f. Stem-Seal Packing: Asbestos free.
   g. Plug, Resilient-Seating Material: Suitable for potable-water service unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

C. Examine threads on valve and mating pipe for form and cleanliness.

D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.

E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.

B. Locate valves for easy access and provide separate support where necessary.

C. Install valves in horizontal piping with stem at or above center of pipe.

D. Install valves in position to allow full stem movement.

E. Install check valves for proper direction of flow and as follows:
   1. Swing Check Valves: In horizontal position with hinge pin level.
   2. Lift Check Valves: With stem upright and plumb.

3.3 ADJUSTING

A. Adjust or replace valve packing after piping systems have been tested and put into service but before final adjusting and balancing. Replace valves if persistent leaking occurs.

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

A. If valve applications are not indicated, use the following:
   1. Shutoff Service: Ball, butterfly, or gate valves.
   2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
   3. Throttling Service except Steam: Globe Globe or angle valves.
   4. Pump-Discharge Check Valves:
      a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
      b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.

B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

C. Select valves, except wafer types, with the following end connections:
   1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
   2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
   4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
   5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
   6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.5 CHILLED-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Bronze Angle Valves: Class 150, nonmetallic disc.
   3. Ball Valves: Two piece, full port, brass or bronze with brass trim.
   4. Bronze Swing Check Valves: Class 150, nonmetallic disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
   2. High-Performance Butterfly Valves: Class 150 Class 300, single flange.
   3. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring weight.
   4. Iron, Grooved-End Check Valves, NPS 3 to NPS 12: 300 CWP.
   5. Lubricated Plug Valves: Class 125, regular gland, flanged.
   6. Eccentric Plug Valves: 175 CWP, resilient seating.

3.6 HEATING-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:
   1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
   2. Ball Valves: Two piece, full port, brass or bronze with brass trim.
   3. Bronze Swing Check Valves: Class 150, nonmetallic disc.

B. Pipe NPS 2-1/2 and Larger:
   1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
   2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
   3. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
   4. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
   5. High-Performance Butterfly Valves: Class 150, single flange.
   6. Iron Swing Check Valves: Class 125, metal seats.
   7. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and spring.
   8. Iron, Center-Guided Check Valves: Class 125, globe, metal seat.
   9. Iron Gate Valves: Class 125, NRS.

END OF SECTION 230523

SECTION 230533 - HEAT TRACING FOR HVAC 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 heat tracing for HVAC piping with the following electric heating cables:
   1. Plastic insulated, series resistance.

B. Related Requirements:
   1. Section 220533 "Heat Tracing for Plumbing Piping."

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
   2. Schedule heating capacity, length of cable, spacing, and electrical power requirement for each electric heating cable required.

B. Shop Drawings: For electric heating cable.
   1. Include plans, elevations, sections, and attachment details.
   2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For electric heating cables to include in operation and maintenance manuals.

1.6 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace electric heating cable that fails in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PLASTIC-INSULATED, SERIES-RESISTANCE HEATING CABLES

A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Delta-Therm Corporation.
2. Easy Heat; a division of EGS Electrical Group LLC.
3. Orbit Manufacturing.
4. Pyrotenax; a brand of Tyco Thermal Controls LLC.
5. Raychem; a brand of Tyco Thermal Controls LLC.
6. Watts Radiant, Inc.; a subsidiary of Watts Water Technologies, Inc.

B. Comply with IEEE 515.1.

C. Heating Element: Single- or dual-stranded resistor wire. Terminate with waterproof, factory-assembled, nonheating leads with connectors at both ends.

D. Electrical Insulating Jacket: Minimum 4.0-mil Kapton with silicone, Tefzel, or polyolefin.

E. Cable Cover: Aluminum braid and silicone or Hylar outer jacket.

F. Maximum Operating Temperature (Power On): 150 deg F.

G. Maximum Exposure Temperature (Power Off): 185 deg F.

H. 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.

I. Capacities and Characteristics:
1. Maximum Heat Output: 6 W/ft. maximum.
2. Piping Diameter: Refer to floor plans.
3. Electrical Characteristics for Single-Circuit Connection:

2.2 CONTROLS

A. Remote bulb unit with adjustable temperature range from 30 to 50 deg F.

B. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected cable.

C. Remote bulb on capillary, resistance temperature device, or thermistor for directly sensing pipe-wall temperature.

D. Corrosion-resistant, waterproof control enclosure.

2.3 ACCESSORIES

A. Cable Installation Accessories: Fiberglass tape, heat-conductive putty, cable ties, silicone end seals and splice kits, and installation clips all furnished by manufacturer, or as recommended in writing by manufacturer.

B. Warning Labels: Refer to Section 230553 "Identification for HVAC Piping and Equipment."

C. Warning Tape: Continuously printed "Electrical Tracing"; vinyl, at least 3 mils thick, and with pressure-sensitive, permanent, waterproof, self-adhesive back.
   1. Width for Markers on Pipes with OD, Including Insulation, Less Than 6 Inches: 3/4 inch minimum.
   2. Width for Markers on Pipes with OD, Including Insulation, 6 Inches or Larger: 1-1/2 inches minimum.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surfaces and substrates to receive electric heating cables for compliance with requirements for installation tolerances and other conditions affecting performance.
   1. Ensure surfaces and pipes in contact with electric heating cables are free of burrs and sharp protrusions.

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

3.2 INSTALLATION

A. Install electric heating cable across expansion joints according to manufacturer's written instructions; use slack cable to allow movement without damage to cable.

B. Install electric heating cables after piping has been tested and before insulation is installed.

C. Install electric heating cables according to IEEE 515.1.

D. Install insulation over piping with electric cables according to Section 230719 "HVAC Piping Insulation."

E. Install warning tape on piping insulation where piping is equipped with electric heating cables.

F. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
   1. Perform tests after cable installation but before application of coverings such as insulation, wall or ceiling construction, or concrete.
   2. Test cables for electrical continuity and insulation integrity before energizing.
   3. Test cables to verify rating and power input. Energize and measure voltage and current simultaneously.

D. Repeat tests for continuity, insulation resistance, and input power after applying thermal insulation on pipe-mounted cables.

E. Cables will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.5 PROTECTION

A. Protect installed heating cables, including nonheating leads, from damage during construction.

B. Remove and replace damaged heat-tracing cables.

END OF SECTION 230533

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Equipment labels.
2. Warning signs and labels.
3. Pipe labels.
4. Duct labels.
5. Stencils.
6. Valve tags.
7. Warning tags.

1.3 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Samples: For color, letter style, and graphic representation required for each identification material and device.

C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.

D. Valve numbering scheme.

E. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

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

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

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

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Metal Labels for Equipment:
1. Material and Thickness: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.
3. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
4. Fasteners: Stainless-steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

C. Label Content: Include equipment's Drawing designation or unique equipment number.

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

2.2 WARNING SIGNS AND LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: White.

C. Background Color: Red.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.3 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: At least 1-1/2 inches high.

2.4 DUCT LABELS

A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/16 inch thick, and having predrilled holes for attachment hardware.

B. Letter Color: Black.

C. Background Color: White.

D. Maximum Temperature: Able to withstand temperatures up to 160 deg F.

E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 1 inch.

F. Minimum Letter Size: 3/4 inch for name of units. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

G. Fasteners: Stainless-steel rivets or self-tapping screws.

H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

I. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
   1. Stencil Material: Aluminum.
   2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
   3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated.

2.6 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 wire-link chain.

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.
   1. Valve-tag schedule shall be included in operation and maintenance data.

2.7 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
   1. Size: Approximately 4 by 7 inches.
   2. Fasteners: Reinforced grommet and wire or string.
   3. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
   4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.1 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. Piping Color-Coding: Painting of piping is specified in Division 09.

B. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels , complying with ASME A13.1, on each piping system.
1. Identification Paint: Use for contrasting background.
2. Stencil Paint: Use for pipe marking.

C. 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.

D. Pipe Label Color Schedule:
1. Chilled-Water Piping:
   a. Background Color: Green.
   b. Letter Color: White.
   c. Letter Color: White.
2. Heating Water Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.
3. Low-Pressure Steam Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.
4. Steam Condensate Piping:
   a. Background Color: Yellow.
   b. Letter Color: Black.

3.4 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:
1. Blue: For cold-air supply ducts.
2. Yellow: For hot-air supply ducts.
3. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
4. ASME A13.1 Colors and Designs: For hazardous material exhaust.

B. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than 1 inch high is needed for proper identification because of distance from normal location of required identification.

C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; 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.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
   1. Valve-Tag Size and Shape:
      a. Chilled Water: 1-1/2 inches, round.
      b. Hot Water: 1-1/2 inches, round.
      c. Gas: 1-1/2 inches, round.
      d. Low-Pressure Steam: 1-1/2 inches, round.
      e. Steam Condensate: 1-1/2 inches, round.
   2. Valve-Tag Color:
      a. Chilled Water: Green.
      b. Hot Water: Yellow.
      c. Low-Pressure Steam: Yellow.
      d. Steam Condensate: Yellow.
   3. Letter Color:
      a. Chilled Water: White.
      b. Hot Water: Black.
      c. Low-Pressure Steam: Black.
      d. Steam Condensate: Black.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION 230553

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING 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. Section Includes:
   1. Balancing Air Systems:
      a. Variable-air-volume systems.
   2. Balancing Hydronic Piping Systems:
      a. Variable-flow hydronic systems.

1.3 DEFINITIONS

A. AABC: Associated Air Balance Council.

B. NEBB: National Environmental Balancing Bureau.

C. TAB: Testing, adjusting, and balancing.

D. TABB: Testing, Adjusting, and Balancing Bureau.

E. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

B. Contract Documents Examination Report: Within 30 days of Contractor's Notice to Proceed, submit the Contract Documents review report as specified in Part 3.

C. Strategies and Procedures Plan: Within 60 days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.

D. Certified TAB reports.

E. Sample report forms.

F. Instrument calibration reports, to include the following:
   1. Instrument type and make.
   2. Serial number.
   3. Application.

4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

A. TAB Contractor Qualifications: Engage a TAB entity certified by AABC NEBB or TABB.
   1. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC NEBB or TABB.
   2. TAB Technician: Employee of the TAB contractor and who is certified by AABC NEBB or TABB as a TAB technician.

B. TAB Conference: Meet with Construction Manager and Commissioning Authority on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide seven days' advance notice of scheduled meeting time and location.
   1. Agenda Items:
      a. The Contract Documents examination report.
      b. The TAB plan.
      c. Coordination and cooperation of trades and subcontractors.
      d. Coordination of documentation and communication flow.

C. Certify TAB field data reports and perform the following:
   1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
   2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.

D. TAB Report Forms: Use standard TAB contractor's forms approved by Construction Manager and Commissioning Authority.

E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

G. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

A. Full Owner Occupancy: Owner will occupy the site and existing building during entire TAB period. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

B. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.

B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.

B. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

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 ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Section 233113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.

F. Examine equipment performance data including fan and pump curves.
   1. 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.
   2. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.

G. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

H. Examine test reports specified in individual system and equipment Sections.

I. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

J. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

K. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.

L. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.

M. Examine heat-transfer coils for correct piping connections and for clean and straight fins.

N. Examine system pumps to ensure absence of entrained air in the suction piping.

O. Examine operating safety interlocks and controls on HVAC equipment.

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

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.
1. Comply with requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
1. After testing and balancing, install test ports and duct access doors that comply with requirements in Section 233300 "Air Duct Accessories."
2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Section 230713 "Duct Insulation," Section 230716 "HVAC Equipment Insulation," and Section 230719 "HVAC Piping Insulation."

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.4 PROCEDURES FOR DUAL-DUCT SYSTEMS

A. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.

B. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
   1. If insufficient static pressure exists, increase airflow at the fan.

C. Test and adjust the constant-volume mixing boxes as follows:
   1. Verify both hot and cold operations by adjusting the thermostat and observing changes in air temperature and volume.
   2. Verify sufficient inlet static pressure before making volume adjustments.
   3. Adjust mixing boxes to indicated airflows within specified tolerances. Measure airflow by Pitot-tube traverse readings or by measuring static pressure at mixing-box taps if provided by mixing-box manufacturer.

D. Do not overpressurize ducts.

E. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.

F. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.

3.5 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.

B. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
   1. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
   2. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
   3. Measure total system airflow. Adjust to within indicated airflow.
   4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
   5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
      a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

6. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
7. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
8. Record final fan-performance data.

C. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Balance variable-air-volume systems the same as described for constant-volume air systems.
2. Set terminal units and supply fan at full-airflow condition.
3. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
4. Readjust fan airflow for final maximum readings.
5. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
6. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
7. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
    a. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
8. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    a. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

D. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
1. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
2. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
3. Set terminal units at full-airflow condition.
4. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
5. Adjust terminal units for minimum airflow.
6. Measure static pressure at the sensor.
7. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.

3.6 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the 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 liquid level in expansion tank.
   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 CONSTANT-FLOW 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.
      a. If impeller sizes must be adjusted to achieve pump performance, obtain approval from Construction Manager and Commissioning Authority and comply with requirements in Section 232123 "Hydronic Pumps."
   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.
      a. Monitor motor performance during procedures and do not operate motors in overload conditions.
   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 10 percent of design.

B. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.

C. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.

D. Set calibrated balancing valves, if installed, at calculated presettings.

E. Measure flow at all stations and adjust, where necessary, to obtain first balance.
   1. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.

F. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.

G. 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.

H. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.

I. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.

J. Check settings and operation of each safety valve. Record settings.

3.8 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

A. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

3.9 PROCEDURES FOR MOTORS

A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
1. Manufacturer's name, model number, and serial number.
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 of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.10 PROCEDURES FOR TESTING, ADJUSTING, AND BALANCING EXISTING SYSTEMS

A. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
1. Measure and record the operating speed, airflow, and static pressure of each fan.
2. Measure motor voltage and amperage. Compare the values to motor nameplate information.
3. Check the refrigerant charge.
4. Check the condition of filters.
5. Check the condition of coils.
6. Check the operation of the drain pan and condensate-drain trap.
7. Check bearings and other lubricated parts for proper lubrication.
8. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

B. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:

1. New filters are installed.
2. Coils are clean and fins combed.
3. Drain pans are clean.
4. Fans are clean.
5. Bearings and other parts are properly lubricated.
6. Deficiencies noted in the preconstruction report are corrected.

C. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
1. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
2. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
3. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
4. Balance each air outlet.

3.11 TOLERANCES

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

3.12 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: Prepare weekly progress 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.

3.13 FINAL REPORT

A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.

B. 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; do not include Shop Drawings and product data.

C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
2. Name and address of the TAB contractor.
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 supervisor 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's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:
    a. Settings for outdoor-, return-, and exhaust-air dampers.
    b. Conditions of filters.
    c. Cooling coil, wet- and dry-bulb conditions.
    d. Face and bypass damper settings at coils.
    e. Fan drive settings including settings and percentage of maximum pitch diameter.
    f. Inlet vane settings for variable-air-volume systems.
    g. Settings for supply-air, static-pressure controller.
    h. Other system operating conditions that affect performance.

D. 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 outdoor, 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.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:
    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, and bore.
    i. Center-to-center dimensions of sheave, and amount of adjustments in inches.

j. Number, make, and size of belts.
k. Number, type, and size of filters.

2. Motor Data:
   a. Motor 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, and bore.
   f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
   a. Total air flow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Filter static-pressure differential in inches wg.
   f. Preheat-coil static-pressure differential in inches wg.
   g. Cooling-coil static-pressure differential in inches wg.
   h. Heating-coil static-pressure differential in inches wg.
   i. Outdoor airflow in cfm.
   j. Return airflow in cfm.
   k. Outdoor-air damper position.
   l. Return-air damper position.
   m. Vortex damper position.

F. Apparatus-Coil Test Reports:
1. Coil Data:
   a. System identification.
   b. Location.
   c. Coil type.
   d. Number of rows.
   e. Fin spacing in fins per inch o.c.
   f. Make and model number.
   g. Face area in sq. ft..
   h. Tube size in NPS.
   i. Tube and fin materials.
   j. Circuiting arrangement.
2. Test Data (Indicated and Actual Values):
   a. Air flow rate in cfm.
   b. Average face velocity in fpm.
   c. Air pressure drop in inches wg.
   d. Outdoor-air, wet- and dry-bulb temperatures in deg F.
   e. Return-air, wet- and dry-bulb temperatures in deg F.
   f. Entering-air, wet- and dry-bulb temperatures in deg F.
   g. Leaving-air, wet- and dry-bulb temperatures in deg F.
   h. Water flow rate in gpm.
   i. Water pressure differential in feet of head or psig.
   j. Entering-water temperature in deg F.
   k. Leaving-water temperature in deg F.
   l. Refrigerant expansion valve and refrigerant types.
   m. Refrigerant suction pressure in psig.
   n. Refrigerant suction temperature in deg F.
   o. Inlet steam pressure in psig.

G. 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, and bore.
h. Center-to-center dimensions of sheave, and amount of adjustments in inches.

2. Motor Data:
a. Motor 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, and bore.
f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
g. Number, make, and size of belts.

3. Test Data (Indicated and Actual Values):
a. Total airflow rate in cfm.
b. Total system static pressure in inches wg.
c. Fan rpm.
d. Discharge static pressure in inches wg.
e. Suction static pressure in inches wg.

H. Round, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:
a. System and air-handling-unit number.
b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft..
g. Indicated air flow rate in cfm.
h. Indicated velocity in fpm.
i. Actual air flow rate in cfm.
j. Actual average velocity in fpm.
k. Barometric pressure in psig.
l.

I. 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. Air flow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.
e. Entering-air temperature in deg F.
f. Leaving-air temperature in deg F.

J. Instrument Calibration Reports:

1. Report Data:
a. Instrument type and make.

b. Serial number.
c. Application.
d. Dates of use.
e. Dates of calibration.

3.14 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. Check the following for each system:
a. Measure airflow of at least 10 percent of air outlets.
b. Measure water flow of at least 5 percent of terminals.
c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
d. Verify that balancing devices are marked with final balance position.
e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:
1. After initial inspection is complete and documentation 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 Construction Manager and Commissioning Authority.
2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Construction Manager and Commissioning Authority.
3. Construction Manager and Commissioning Authority shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
4. If 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.

C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.

D. Prepare test and inspection reports.

3.15 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB 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 TAB during near-peak summer and winter conditions.

END OF SECTION 230593

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following duct services:
   1. Outdoor, concealed supply and return.
   2. Outdoor, exposed supply and return.

1.3 ACTION SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
   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, dampers, specialties and flanges for each type of insulation.
   3. Detail application of field-applied jackets.
   4. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use. Sample sizes are as follows:
   1. Sheet Form Insulation Materials: 12 inches square.
   2. Sheet Jacket Materials: 12 inches square.
   3. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer.

B. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

C. Field quality-control reports.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
   1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
   2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.8 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Duct Insulation Schedule, General," "Indoor Duct and Plenum Insulation Schedule," and "Aboveground, Outdoor Duct and Plenum Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type II for sheet materials.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aerocel.
   b. Armacell LLC; AP Armaflex.
   c. ArmaTuff with exterior aluminum cladding (basis of design)

2.2 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Aeroflex USA, Inc.; Aeroseal.
   b. Armacell LLC; Armaflex 520 Adhesive.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.K-Flex USA; R-373 Contact Adhesive.
2. Adhesive 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."

C. ASJ Adhesive, and FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-82.
   b. Eagle Bridges - Marathon Industries; 225.
   c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-50.Mon-Eco Industries, Inc.; 22-25.
2. Adhesive 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."

2.3 SEALANTS

A. FSK and Metal Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.Eagle Bridges - Marathon Industries; 405.
   b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
   c. Mon-Eco Industries, Inc.; 44-05.
2. Materials shall be compatible with insulation materials, jackets, and substrates.

3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

B. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants:
1. Products: Subject to compliance with requirements, provide the following:
   a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealants 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."

2.4 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. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
1. Products: Subject to compliance with requirements, provide one of the following:
   a. Johns Manville; Zeston.
   b. P.I.C. Plastics, Inc.; FG Series.
   c. Proto Corporation; LoSmoke.
   d. Speedline Corporation; SmokeSafe.
2. Adhesive: As recommended by jacket material manufacturer.
3. Color: White.
4. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
   a. Sheet and roll stock ready for shop or field sizing.
   b. Material, finish, and thickness are indicated in field-applied jacket schedules.
   c. Moisture Barrier for Indoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.
   d. Moisture Barrier for Outdoor Applications: 3-mil-thick, heat-bonded polyethylene and kraft paper.

D. Self-Adhesive Outdoor Jacket: 60-mil-thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white aluminum-foil facing.
1. Products: Subject to compliance with requirements, provide the following:
   a. Polyguard Products, Inc.; Alumaguard 60.

2.5 TAPES

A. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
1. Products: Subject to compliance with requirements, provide one of the following:
a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.
2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

PART 3 - EXECUTION

3.1 EXAMINATION

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

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

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.

B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

H. Install insulation with least number of joints practical.

I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

K. Install insulation with factory-applied jackets as follows:
1. Draw jacket tight and smooth.
2. Cover circumferential joints with 3-inch-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. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
   a. For below ambient services, apply vapor-barrier mastic over staples.
4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

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

3.4 PENETRATIONS

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

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.

2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 3inches.
4. Seal jacket to wall flashing with flashing sealant.

3.5 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

3.6 FIELD-APPLIED JACKET INSTALLATION

A. Where FSK jackets are indicated, install as follows:
1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

B. Where metal jackets are indicated, install with 2-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.

3.7 FIRE-RATED INSULATION SYSTEM INSTALLATION

A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.

B. Insulate duct access panels and doors to achieve same fire rating as duct.

C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:
1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.9 DUCT INSULATION SCHEDULE, GENERAL

A. Ducts Requiring Insulation:
   1. All Outdoor, concealed and exposed supply, exhaust and return.
   2. All insulation shall be minimum thickness of 2".
   3. Insulation shall be ArmaTuff with aluminum shield cladding.

B. Items Not Insulated:
   1. Factory-insulated flexible ducts.
   2. Flexible connectors.
   3. Vibration-control devices.
   4. Factory-insulated access panels and doors.

END OF SECTION 230713

SECTION 230719 - PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes insulating the following HVAC piping systems:

1. Condensate drain piping
2. Chilled-water piping
3. Heating hot-water piping

1.3 SUBMITTALS

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

B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
2. Detail attachment and covering of heat tracing inside insulation.
3. Detail insulation application at pipe expansion joints for each type of insulation.
4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
5. Detail removable insulation at piping specialties.
6. Detail application of field-applied jackets.
7. Detail application at linkages of control devices.

C. Samples: For each type of insulation and jacket indicated. Identify each Sample, describing product and intended use.

1. Preformed Pipe Insulation Materials: 12 inches long by NPS 2.
2. Sheet Form Insulation Materials: 12 inches square.
3. Jacket Materials for Pipe: 12 inches long by NPS 2.
4. Sheet Jacket Materials: 12 inches square.
5. Manufacturer's Color Charts: For products where color is specified, show the full range of colors available for each type of finish material.

D. Qualification Data: For qualified Installer.

E. Material Test Reports: From a qualified testing agency acceptable to authorities having jurisdiction indicating, interpreting, and certifying test results for compliance of insulation materials,

sealers, attachments, cements, and jackets, with requirements indicated. Include dates of tests and test methods employed.

F. Field quality-control reports.

1.4 QUALITY ASSURANCE

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

C. Mockups: Before installing insulation, build mockups for each type of insulation and finish listed below to demonstrate quality of insulation application and finishes. Build mockups in the location indicated or, if not indicated, as directed by Architect. Use materials indicated for the completed Work.

1. Piping Mockups:

a. One 10-foot section of NPS 2 straight pipe.
b. One each of a 90-degree threaded, welded, and flanged elbow.
c. One each of a threaded, welded, and flanged tee fitting.
d. One NPS 2 or smaller valve, and one NPS 2-1/2 or larger valve.
e. Four support hangers including hanger shield and insert.
f. One threaded strainer and one flanged strainer with removable portion of insulation.
g. One threaded reducer and one welded reducer.
h. One pressure temperature tap.
i. One mechanical coupling.

2. For each mockup, fabricate cutaway sections to allow observation of application details for insulation materials, adhesives, mastics, attachments, and jackets.
3. Notify Architect seven days in advance of dates and times when mockups will be constructed.
4. Obtain Architect's approval of mockups before starting insulation application.
5. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.
6. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
7. Demolish and remove mockups when directed.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."

B. Coordinate clearance requirements with piping Installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

C. Coordinate installation and testing of heat tracing.

1.7 SCHEDULING

A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Comply with requirements in "Piping Insulation Schedule, General," "Indoor Piping Insulation Schedule," "Outdoor, Aboveground Piping Insulation Schedule," and "Outdoor, Underground Piping Insulation Schedule" articles for where insulating materials shall be applied.

B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.

D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

F. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

a. Pittsburgh Corning Corporation; Foamglass.

2. Block Insulation: ASTM C 552, Type I.
3. Special-Shaped Insulation: ASTM C 552, Type III.
4. Board Insulation: ASTM C 552, Type IV.
5. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
6. Preformed Pipe Insulation with Factory-Applied ASJ: Comply with ASTM C 552, Type II, Class 2.
7. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.

G. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

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

a. Aeroflex USA, Inc.; Aerocel.
b. Armacell LLC; AP Armaflex.
c. K-Flex USA; Insul-Lock, Insul-Tube, and K-FLEX LS.

H. 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 II with factory-applied vinyl jacket. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

a. CertainTeed Corp.; SoftTouch Duct Wrap.
b. Johns Manville; Microlite.
c. Knauf Insulation; Friendly Feel Duct Wrap.
d. Manson Insulation Inc.; Alley Wrap.
e. Owens Corning; SOFTR All-Service Duct Wrap.

I. Mineral-Fiber, Preformed Pipe Insulation:

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

a. Fibrex Insulations Inc.; Coreplus 1200.
b. Johns Manville; Micro-Lok.
c. Knauf Insulation; 1000-Degree Pipe Insulation.
d. Manson Insulation Inc.; Alley-K.
e. Owens Corning; Fiberglas Pipe Insulation.

2. Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
3. Type II, 1200 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, with factory-applied ASJ. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

J. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory-applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-

sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.

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

    a. Knauf Insulation; Permawick Pipe Insulation.
    b. Owens Corning; VaporWick Pipe Insulation.

K. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.

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

    a. CertainTeed Corp.; CrimpWrap.
    b. Johns Manville; MicroFlex.
    c. Knauf Insulation; Pipe and Tank Insulation.
    d. Manson Insulation Inc.; AK Flex.
    e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.2 INSULATING CEMENTS

A. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.

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

    a. Ramco Insulation, Inc.; Super-Stik.

B. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.

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

    a. Ramco Insulation, Inc.; Thermokote V.

C. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449.

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

    a. Ramco Insulation, Inc.; Ramcote 1200 and Quik-Cote.

2.3 ADHESIVES

A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.

B. Cellular-Glass Adhesive: Two-component, thermosetting urethane adhesive containing no flammable solvents, with a service temperature range of minus 100 to plus 200 deg F.

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

    a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 81-84.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies 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," including 2004 Addenda.

C. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.

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

    a. Aeroflex USA, Inc.; Aeroseal.
    b. Armacell LLC; Armaflex 520 Adhesive.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-75.
    d. K-Flex USA; R-373 Contact Adhesive.

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies 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," including 2004 Addenda.

D. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-127.
    b. Eagle Bridges - Marathon Industries; 225.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 85-60/85-70.
    d. Mon-Eco Industries, Inc.; 22-25.

2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies 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," including 2004 Addenda.

E. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.

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

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

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Use adhesive that complies 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," including 2004 Addenda.

2.4 MASTICS

A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-PRF-19565C, Type II.

1. For indoor applications, use mastics that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Vapor-Barrier Mastic: Water based; suitable for indoor use on below-ambient services.

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

   a. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-80/30-90.
   b. Vimasco Corporation; 749.

2. Water-Vapor Permeance: ASTM E 96/E 96M, Procedure B, 0.013 perm at 43-mil dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: ASTM D 1644, 58 percent by volume and 70 percent by weight.
5. Color: White.

C. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below-ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-30.
b. Eagle Bridges - Marathon Industries; 501.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-35.
d. Mon-Eco Industries, Inc.; 55-10.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 35-mil dry film thickness.
3. Service Temperature Range: 0 to 180 deg F.
4. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
5. Color: White.

D. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below-ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; Encacel.
b. Eagle Bridges - Marathon Industries; 570.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 60-95/60-96.

2. Water-Vapor Permeance: ASTM F 1249, 0.05 perm at 30-mil dry film thickness.
3. Service Temperature Range: Minus 50 to plus 220 deg F.
4. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
5. Color: White.

E. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services.

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

a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-10.
b. Eagle Bridges - Marathon Industries; 550.
c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 46-50.
d. Mon-Eco Industries, Inc.; 55-50.
e. Vimasco Corporation; WC-1/WC-5.

2. Water-Vapor Permeance: ASTM F 1249, 1.8 perms at 0.0625-inch dry film thickness.
3. Service Temperature Range: Minus 20 to plus 180 deg F.
4. Solids Content: 60 percent by volume and 66 percent by weight.
5. Color: White.

2.5 LAGGING ADHESIVES

A. Description: Comply with MIL-A-3316C, Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.

1. For indoor applications, use lagging adhesives that have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-50 AHV2.
    b. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-36.
    c. Vimasco Corporation; 713 and 714.

3. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over pipe insulation.
4. Service Temperature Range: 0 to plus 180 deg F.
5. Color: White.

2.6 SEALANTS

A. Joint Sealants:

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 30-45.
    d. Mon-Eco Industries, Inc.; 44-05.
    e. Pittsburgh Corning Corporation; Pittseal 444.

B. FSK and Metal Jacket Flashing Sealants:

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

    a. Childers Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; CP-76.
    b. Eagle Bridges - Marathon Industries; 405.
    c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller Company; 95-44.
    d. Mon-Eco Industries, Inc.; 44-05.

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: Aluminum.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emis-

sions from Various Sources Using Small-Scale Environmental Chambers," including 2004 Addenda.

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

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

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

2. Materials shall be compatible with insulation materials, jackets, and substrates.
3. Fire- and water-resistant, flexible, elastomeric sealant.
4. Service Temperature Range: Minus 40 to plus 250 deg F.
5. Color: White.
6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Use sealants that 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," including 2004 Addenda.

2.7 FACTORY-APPLIED JACKETS

A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:

1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
2. PVDC Jacket for Outdoor Applications: 6-mil-thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

   a. Products: Subject to compliance with requirements, provide the following:

      1) Dow Chemical Company (The); Saran 540 Vapor Retarder Film and Saran 560 Vapor Retarder Film.

3. Vinyl Jacket: White vinyl with a permeance of 1.3 perms when tested according to ASTM E 96/E 96M, Procedure A, and complying with NFPA 90A and NFPA 90B.

2.8 TAPES

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.

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

   a. ABI, Ideal Tape Division; 428 AWF ASJ.

b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
c. Compac Corporation; 104 and 105.
d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.

2. Width: 3 inches.
3. Thickness: 11.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.

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

a. ABI, Ideal Tape Division; 491 AWF FSK.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
c. Compac Corporation; 110 and 111.
d. Venture Tape; 1525 CW NT, 1528 CW, and 1528 CW/SQ.

2. Width: 3 inches.
3. Thickness: 6.5 mils.
4. Adhesion: 90 ounces force/inch in width.
5. Elongation: 2 percent.
6. Tensile Strength: 40 lbf/inch in width.
7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

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

a. ABI, Ideal Tape Division; 488 AWF.
b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
c. Compac Corporation; 120.
d. Venture Tape; 3520 CW.

2. Width: 2 inches.
3. Thickness: 3.7 mils.
4. Adhesion: 100 ounces force/inch in width.
5. Elongation: 5 percent.
6. Tensile Strength: 34 lbf/inch in width.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

B. Surface Preparation: Clean and prepare surfaces to be insulated. 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.

C. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

D. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.3 GENERAL INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs.

E. Install multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Keep insulation materials dry during application and finishing.

H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.

I. Install insulation with least number of joints practical.

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.

K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

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.

    a. For below-ambient services, apply vapor-barrier mastic over staples.

4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.

M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

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

P. For above-ambient services, do not install insulation to the following:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

3.4 PENETRATIONS

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
4. Seal jacket to roof flashing with flashing sealant.

B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.

C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
4. Seal jacket to wall flashing with flashing sealant.

D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

E. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

F. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
8. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
9. Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

D. Install removable insulation covers at locations indicated. Installation shall conform to the following:

1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.

4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF CELLULAR-GLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.7 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

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

B. Insulation Installation on Pipe Flanges:

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

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 INSTALLATION OF MINERAL-FIBER INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

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

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
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. Insulation Installation on Valves and Pipe Specialties:

1. Install preformed sections of same material as straight segments of pipe insulation when available.
2. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
3. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
4. Install insulation to flanges as specified for flange insulation application.

3.9 FIELD-APPLIED JACKET INSTALLATION

A. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.

1. Draw jacket smooth and tight to surface with 2-inch overlap at seams and joints.
2. Embed glass cloth between two 0.062-inch-thick coats of lagging adhesive.
3. Completely encapsulate insulation with coating, leaving no exposed insulation.

B. Where FSK jackets are indicated, install as follows:

1. Draw jacket material smooth and tight.
2. Install lap or joint strips with same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.

C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturer's recommended adhesive.

1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

D. Where metal jackets are indicated, install with 2-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.

E. Where PVDC jackets are indicated, install as follows:

1. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
2. Wrap factory-presized jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of 2 inches over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
3. Continuous jacket can be spiral-wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
4. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of 33-1/2 inches or less. The 33-1/2-inch-circumference limit allows for 2-inch-overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
5. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.

3.10 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.

a. Finish Coat Material: Interior, flat, latex-emulsion size.

B. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

D. Do not field paint aluminum or stainless-steel jackets.

3.11 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Perform tests and inspections.

C. Tests and Inspections:

1. Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two loca-

tions of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

D. All insulation applications will be considered defective Work if sample inspection reveals non-compliance with requirements.

3.12 PIPING INSULATION SCHEDULE, GENERAL

A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.

B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:

1. Drainage piping located in crawl spaces.
2. Underground piping.
3. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.13 INDOOR PIPING INSULATION SCHEDULE

A. Condensate and Equipment Drain Water below 60 Deg F:

1. All Pipe Sizes: Insulation shall be the following:

a. Cellular Glass: 1-1/2 inches thick.

B. Chilled Water, 40 Deg F and below:

1. NPS 3 and Smaller: Insulation shall be the following:

a. Cellular Glass: 1-1/2 inches thick.

2. NPS 4 to NPS 12: Insulation shall be the following:

a. Cellular Glass: 1-1/2 inches thick.

C. Chilled Water, above 40 Deg F:

1. NPS 12 and Smaller: Insulation shall be the following:

a. Cellular Glass: 1-1/2 inches thick.
b. Flexible Elastomeric: 1 inch thick.

D. Heating-Hot-Water Supply and Return, 200 Deg F and Below:

1. NPS 12 and Smaller: Insulation shall be the following:

a. Cellular Glass: 1-1/2 inches thick.

3.14 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE

A. Chilled Water:

1. All Pipe Sizes: Insulation shall be the following:

a. Cellular Glass: 3 inches thick.

3.15 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.

B. Chilled Water, All Sizes: Cellular glass, 2 inches thick.

C. Steam and Steam Condensate, All Sizes, 350 Deg F and Below:

1. Cellular Glass: 4 inches thick.

D. Steam and Steam Condensate, All Sizes, above 350 Deg F:

1. Cellular Glass: 5 inches thick.

3.16 INDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Aluminum, Smooth: 0.016 inch thick.
2. Painted Aluminum, Smooth: 0.016 inch thick.

D. Piping, Exposed:

1. Aluminum, Smooth: 0.016 inch thick.
2. Painted Aluminum, Smooth: 0.016 inch thick.

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.

B. If more than one material is listed, selection from materials listed is Contractor's option.

C. Piping, Concealed:

1. Aluminum, Smooth: 0.016 inch thick.
2. Painted Aluminum, Smooth: 0.016 inch thick.

D. Piping, Exposed:

1. Painted Aluminum, Smooth with Z-Shaped Locking Seam: 0.016 inch thick.

END OF SECTION 230719

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.

B. Related Sections:
1. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.3 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase controls coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in HVAC&R systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.4 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:
1. Plan for review of submittals and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for HVAC&R systems, assemblies, equipment, and components to be verified and tested.
4. Certificate of completion certifying that installation, prestart checks, and startup procedures have been completed.
5. Certificate of readiness certifying that HVAC&R systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.

8. Verification of testing, adjusting, and balancing reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TESTING PREPARATION

A. Verify that HVAC&R systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Verify 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. Verify 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.

3.2 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 for review.

B. Notify the CxA at least 10 working 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 working 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.

3.3 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. The CxA along with the HVAC&R Contractor, testing and balancing Contractor, and HVAC&R Instrumentation and Control Contractor shall prepare detailed testing plans, procedures, and checklists for HVAC&R systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the HVAC&R system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

J. If the testing plan indicates specific seasonal testing, complete appropriate initial performance tests and documentation and schedule seasonal tests.

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

A. HVAC&R Instrumentation and Control System Testing: Field testing plans and testing requirements are specified in Division 23 Section "Building Management System." Assist the CxA with preparation of testing plans.

B. HVAC&R Contractor shall prepare a pipe system cleaning, flushing, and hydrostatic testing plan. Provide cleaning, flushing, testing, and treating plan and final reports to the CxA. Plan shall include the following:
   1. Sequence of testing and testing procedures for each section of pipe to be tested, identified by pipe zone or sector identification marker. Markers shall be keyed to Drawings for each pipe sector, showing the physical location of each designated pipe test section. Drawings keyed to pipe zones or sectors shall be formatted to allow each section of piping to be physically located and identified when referred to in pipe system cleaning, flushing, hydrostatic testing, and chemical treatment plan.
   2. Description of equipment for flushing operations.
   3. Minimum flushing water velocity.

4. Tracking checklist for managing and ensuring that all pipe sections have been cleaned, flushed, hydrostatically tested, and chemically treated.

C. Energy Supply System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of steam hot-water systems and equipment at the direction of the CxA. The CxA shall determine the sequence of testing and testing procedures for each equipment item and pipe section to be tested.

D. HVAC&R Distribution System Testing: Provide technicians, instrumentation, tools, and equipment to test performance of air, steam, and hydronic distribution systems; special exhaust; and other distribution systems, including HVAC&R terminal equipment and unitary equipment.

E. Vibration and Sound Tests: Provide technicians, instrumentation, tools, and equipment to test performance of vibration isolation and seismic controls.

END OF SECTION 230800

SECTION 230900 – AUTOMATIC TEMPERATURE CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary conditions and other Division 23 specifications Sections, apply to this Section.

B. Installation, application and start up instructions shall be submitted within 30 days of shop drawing approval to facilitate the commissioning process outlined in Section 230800.

C. Coordination with the Commissioning process: the start up, training, and documentation shall be coordinated with the commissioning process and protocols outlined in Section 230800. Attention is called to the requirement for development of start up tests and checklists in the electronic format specified, documentation of the start up and checkout activities via that electronic forum, submittal of operation and maintenance data electronically per those requirements, and approval of functional performance tests related to equipment of this section. Hard copy as-builts and O&M's are required for the owner.

1.2 WORK INCLUDED

A. The contractor under this section shall furnish and install a complete Distributed Digital Control (DDC) system and coordinate with the other buildings trades.

B. The basis of design is Honeywell WEBs-AX System as installed by Calvert Controls.

C. The control contractor shall be responsible for the complete installation with coordination by the contractor as stated above, and all wiring shall conform to applicable local codes, and specific material and installation requirements specified under Division 26.

D. Mechanical contractor shall install all valves, dampers, and wells.

E. Coordination with the Commissioning process: the start up, training, and documentation shall be coordinated with the commissioning process and protocols outlined in Section 230800. Attention is called to the requirement for development of start up tests and checklists in the

electronic format specified, documentation of the start up and checkout activities via that electronic forum, submittal of operation and maintenance data electronically per those requirements, and approval of functional performance tests related to equipment of this section. Hard copy as-builts and O&M's are required for the owner.

F. A coordination meeting shall be arranged with the VFD vendor, engineer and commissioning agent to discuss fan starting for headered systems.

1.3 DESCRIPTION OF WORK

A. It is the intent of this specification to describe the performance requirements of the energy management and control system. The specifications describe the operational functions of the system and present minimal requirements for equipment to accomplish these functions. Any deviation from the desired performance specified or from the equipment specified, shall be detailed in writing, submitted for review, and approved before bid time.

B. Note that the requirements of this section are specific and describe in detail the exact component and system capabilities necessary for the optimum operations of the facility's CCMS. All requirements will be strictly interpreted and enforced by the Engineer. Failure to comply with any provision may result in rejection of the controls contractor. Written approval by addendum is required. Allow a minimum of l0 days before bid date for review of requests for approval.

C. The contractor shall furnish and install all equipment, accessories, wiring and instrument piping required for a complete and functional system. This contractor shall coordinate the work in sections 230900 and 230910.

D. The building control system shall possess a fully modular architecture, permitting expansion through the addition of more sensors, actuators, operator terminals and points.

E. Related Work Specified Elsewhere

1. Instrumentation and Control Equipment - Section 230910.

2. Electrical Work - See Division 26.

F. At least two (2) weeks prior to starting programming, provide ladder and logic diagrams to the Architect and the commissioning agent for review and approval.

G. Provide testing of each sequence, point to point checkout and commissioning shall be performed in accordance with 230800.

1.4 WIRING

A. The entire building control system shall be installed by skilled electricians and mechanics, all of whom are properly trained and qualified for this work. All wiring shall be installed in accordance with the project electrical specifications - Division 26.

B. Supervision and check-out of the system shall be by local branch engineers and technicians directly employed by the control manufacturer.

C. Cabling for trunk lines between AHU controls panels and the existing BAS panel shall be provided by Controls Contractor and shall consist of twisted pair cabling. Specific requirements shall be as required by NEC/UL listed agencies. Cabling may be ran in the same cable tray as provided in Division 26 (if applicable on floors to route to the existing BAS panel), basement and mechanical space wiring shall be ran in conduit.

D. Controls used for smoke control sequences must be UL 864 compliant.

1.5 SUBMITTALS/DRAWINGS

A. The control contractor shall submit prior to installation one set each of installation drawings and control strategies for review by the consultant, and commissioning agent. These drawings shall include the physical location of building control system equipment and system architecture. The complete sequence of operation of the control system shall be provided.

B. Upon completion of the installation and final system adjustment, the control contractor shall provide a full set of as-built drawings of the installation and the control strategies. Electronic format for the as-built drawings and control strategies shall also be submitted.

C. Submit application, and start up instructions for all components. Submit within 30 days of shop drawing approval to facilitate the commissioning process outlined in Section 230800.

D. Coordination with the Commissioning process: the start up, training, and documentation shall be coordinated with the commissioning process and protocols outlined in Section 230800. Attention is called to the requirement for development of start up tests and checklists in the

electronic format specified, documentation of the start up and checkout activities via that electronic forum, submittal of operation and maintenance data electronically per those requirements, and approval of functional performance tests related to equipment of this section.

1.6 TESTING:

A. General: The controls Contractor shall perform site testing and adjustment of the completed CCMS. The controls Contractor is responsible for providing personnel, equipment, instrumentation, and supplies necessary to perform all testing. Written notification of any planned testing shall be given to the contracting officer at least 14 days prior to any test, and in no case shall notice be given until after the controls contractor has received written engineers approval of the test plans and procedures as specified.

1.7 TEST PLAN

A. Prepare a written test plan indicating in a step-by-step, logical fashion, the procedures by which the automatic control system will be tested, adjusted, and checked.

B. Coordination with the Commissioning process: the testing and documentation thereof shall be coordinated with the commissioning process and protocols outlined in Section 230800. Attention is called to the requirement for coordination in the development of start up tests and checklists in the electronic format specified and documentation of the testing activities via that electronic forum.

C. Not less than six (6) weeks prior to testing, provide four (4) copies of the proposed test plan for approval. Meet and discuss the test plan, and make agreed changes to the written plan.

D. Plan shall include, as a minimum, for each system and sub-system of the automatic control work the following:

1. System name.
2. List of devices with brief description of functional purpose of each.
3. A description of the expected signal values transmitted by the sensor.
4. A description of the expected signal values transmitted by the controller to the control device or actuator.
5. A description of the expected values of the control medium from limit-to-limit.

6. A description of the instrumentation required to test the system.

7. A description of the expected field adjustments for transmitter, controller, and control actuator should control parameters fall outside of expected values.

8. A log sheet or sheets on which expected and field read values will be recorded and final field read values indicating that the system is operating in accordance with contract requirements.

9. Sequence of Operations.

E. Test Plans: The Test Plans shall define all the tests required to ensure that the system meets technical, operational, and performance specifications. The Test Plans shall define milestones for the tests, identifying simulation programs, equipment, personnel, facilities, and supplies required. The Test Plans shall identify the capabilities and functions to be tested.

1. Test Procedures and Reports: The Test Procedures shall be developed from the Test Plans and design documentation. The procedures shall consist of detailed instructions for test setup, execution, and evaluation of test results. The Test Reports shall be used to document results of the tests. Reports shall be delivered to the contracting officer within 7 days after completion of each test.

2. All AI and DI points shall be made alarmable. Alarm limits shall be programmed using PPCL. The PPCL shall automatically adjust the alarm limits to plus and minus 2 degrees Fahrenheit from set point or plus and minus 2% of the sensor range from set point. All loop control shall be fine tuned; such that, no alarms or failed conditions shall exist for a demonstrated period of one month for each point or loop. All control panels shall be provided with UPS modules.

1.8 WARRANTY

A. The building control system including all hardware and software components shall be warranted for a period of one-year following the date of beneficial use. Any manufacturing defects arising during this period shall be corrected without cost to the owner.

B. On completion of the job, the control contractor shall have completely adjusted the entire control system. Point to point checkout and commissioning shall be performed in accordance with 230800. He shall arrange to instruct the Owner's designated representative on the operation of the control system and supply him with three (3) copies of the control operating and instruction manuals in addition to the required electronic submittals. He shall obtain from the Owner's representative, a signed receipt that he has received the instruction manuals and complete instruction on the operation of the control system.

C. Conform to the training requirements outlined in the Section 230800. Specifically provide content related to this section for the Training Plan, and provide the persistent documentation of the course electronically. Provide the audio-visual equipment to present the training per that section.

1.9 QUALITY ASSURANCE

A. Material and equipment shall be standard products of Siemens Inc., no substitutions allowed. The standard products shall have been in commercial or industrial use for two (2) years prior to bid opening. The two (2) years use shall include applications of similarly sized equipment and materials used under similar circumstances.

1.10 SUCCESSFUL INSTALLATIONS:

A. A qualified and approved manufacturer for the DDC system must demonstrate at least 5 successful installations of DDC systems. The definition of a successful installation shall be:

1. All DDC hardware must have been completely user installed by personnel routinely engaged, at the time of installation, in the operation and maintenance of reference DDC installation.

2. The reference DDC installation must have operated for a minimum period of one year without any interruption or failure of the DDC system. An interruption or failure of the DDC system shall be defined as loss of any control functions which caused the HVAC or monitored systems to drift into alarm condition for greater than one hour.

3. During the same time period of item (2) above, all DDC software and hardware maintenance problems must have been successfully field diagnosed and repaired by maintenance personnel routinely engaged, at the time of installation, in the operation and maintenance of reference DDC installation. Field diagnostics/troubleshooting by maintenance personnel includes the use of DDC firmware and software diagnostics via a central operators console or RCU portable tester to troubleshoot the system. Field hardware repair shall be defined as plug and pull electronic component replacement. Software maintenance shall include routine system and data file maintenance for backup, uploading, and downloading of data and software, and all necessary reprogramming of RCU commands due to hardware or system operational changes.

4. The DDC manufacturer for this project shall be Calvert Controls. The control system shall be a Honeywell WEBs-AX system.

1.11 SYSTEM DESCRIPTION

A. Direct Digital Controller: The Stand Alone Control Units (hereinafter referred to as RCU's) shall be located strategically within the building near concentrations of systems or devices to be controlled. The number and location are shown on the contract drawings as a minimum. Resident customer user alterable software shall exist in battery backed up RAM in each RCU to accomplish desired energy management and control tasks in a fully stand-alone environment. Controllers must be located in accessible locations.

B. Communication: Global Data Sharing and communication between each RCU shall be executed on a token-passing network. Data collection, reports, and alarms shall be communicated to the existing central computer on an operator definable basis or when polled. Central computer communication shall be achieved by leased phone lines or hard wire from appropriate communications' ports in the RCU. The owner will furnish and maintain all phone lines required in the building.

1.12 SYSTEM REQUIREMENTS

A. The building control system shall be of a fully modular and distributed processing architecture and not rely on a central processor or any other correlating device for sharing of point data among RCU's. The system shall also be expandable by the addition of RCU panels.

PART 2 - PRODUCTS

2.1 MODULAR BUILDING CONTROLLER AND MODULAR BUILDING CONTROLLER HARDWARE (RCU)

A. The system shall be capable of modularly adding a minimum of 100 RCU's in each token-passing network through interconnection of a single twisted pair of shielded wires to the communications terminals of each stand-alone unit. Fault tolerant operation of the network shall guarantee that failure in communication or operation of any RCU in the LAN shall not interrupt the communication between remaining units. Communication speed shall be not less than 9600 baud. All RCU's may be accessed via the network through peripheral ports on any of the network RCU's. All peripheral communications, as well as global data transfer between network units, shall be accomplished without requirement for central processing computers. Each RCU shall have a minimum point capacity of l000 hardware (physical) points distributed on point expansion units connected to the LAN.

B. The RCU shall include a 24 hour time-of-day clock with calendar and full battery back-up to maintain clock, building operating program and RAM memory for a minimum of 60 days. A built-in charging circuit shall maintain battery at full charge. Each panel shall be connected to emergency power and provided with a UPS module.

C. The existing central computer shall allow access and programming to each of the RCU units in this and existing buildings. Additions or deletions shall be made when the system is on-line. Systems requiring shutdown of any part of the system or program for changes or point editing shall not be acceptable.

D. Each RCU shall have a RS-232 port for connection of a CRT, printer, or modem.

E. The initial program, once entered into the RCU shall be capable of storage at the existing console through a memory dump process and therefore be available to the operator for re-loading as needed.

F. The RCU input/output hardware shall be compatible with electronic and pneumatic HVAC control systems for total building optimization and energy management.

G. The RCU shall be capable of dial-up communication through a telephone modem and a standard telephone line to a remote terminal. A single modem on the network shall communicate with all RCU units connected to a network. The system shall also be capable of being accessed through the internet.

H. The RCU shall be furnished with a user programmable language and internal memory of at least 1 MB RAM to provide the following user definable software capability: electric demand limiting, time programmed commands to include two state and set point control, duty cycle control, optimum start-up control, holiday scheduling, time of day, password entry, and direct digital control with P.I.D. In addition to the above EMS and HVAC control capacity, provisions shall be made for on-line programming and override, and user assigned trend log output to a printer.

I. The data shall be capable of being stored at the central computer after performing a memory dump procedure. Data that is unique for the particular facility shall reside in RAM which will enable the operator to enter the individual program parameters, such as on/off times, demand set point limits, etc. These entries shall be provided with a minimum 60 day battery back-up on all volatile memory components in the event of a power failure.

J. The software shall be capable of communication with a CRT or CPU by use of auto-answer telephone modems and standard dial-up phone lines, as well as direct hard wire. It will be

possible to interrogate memory, change memory elements, or manually override building equipment via the existing CPU or remote console.

K. Program upload/download shall be possible between RCU's on the network, or from the existing central computer.

L. Input/Output: The input/output (I/O) capacity of each RCU with point expansion units shall be not less than l000 hardware data input/output points to include sensors, contacts, two-state commands, binary counters or analog outputs. The RCU will utilize point modules, which snap into the wiring block. Each AI, DI, and DO module will contain a minimum of two points. Each AO module may contain a minimum of one point. The system shall have snap in style terminal strips for connection of input/output wiring. The terminal strips will be separate from the point module so that point modules can be replaced without the need to disconnect wires.

M. The RCU shall execute two state commands to loads, such as stop/start, day/night, open/closed, etc. The RCU shall provide a normally closed or open dry contact output with a minimum contact rating of 8 amps at l20 volts. Each stop/start module shall contain an integral HOA switch that will allow the operator to override the automatic mode.

N. The RCU shall accept an input voltage of 0 to 2V for OFF and l0 to 24V for an ON, which can represent status or alarm signals from monitored devices, or can count pulses from an energy demand generator.

O. The RCU shall provide output signals of l to11 volts DC, 4 to 20mA or 3 to15 PSI. The analog signals must be software scaled to read-out in actual engineering units.

P. The RCU shall accommodate resistive RTD's as specified elsewhere. The analog input board shall accept l to 11 volts or 4 to 20 mA dc. Analog inputs will be scaled to read-out in engineering units, as appropriate.

Q. Displayed data and values are to be automatically accompanied with operator defined English language point descriptors having not less than twelve characters. The RCU shall utilize an 80-character display to provide the operator with a self-prompting technique of entering data into the system. This prompting program automatically steps the operator through the data entry procedure.

R. In addition to the self-prompting programmability, the display may be set up in a mode to automatically scan either analog inputs, digital inputs, analog outputs, or relay (digital) outputs, displaying the value or status of each in sequence. For example, the operator can set the system up to provide a continual display/summary of all or a portion of all of the input sensors, displaying for a few seconds at a time, each value, and then advancing to the next

sensor. This display mode will continue, uninterrupted until manually stopped by an authorized operator.

S. Remote stand-alone RCU control panels operating on the network shall gather, compute, store and deliver to the existing central computer at the owners central EMS office all necessary information for alarms, maintenance time reminders, trends, logs and energy usage data. All operating application programs shall reside in the RCU and will operate without intervention from the existing central computer. Editing and overriding local stand-alone programs shall be possible from the existing central computer, as well as locally at each RCU.

T. The RCU shall be capable of parenthetical, mathematical calculation and logic decisions as programmed by an operator.

U. The RCU shall format all data for recall by the existing central computer. Formats will include such items as Engineering units (KWH, DEG F, DEG C, PSI, VOLTS, ETC.), function descriptions, times, dates and other related information relating to point types.

V. The network shall be able to detect changes in any RCU's point status and report this change to the main console terminal and all other terminals accessing the network.

W. The network shall provide advisories to verify the integrity of the RCU's and their points. The system shall report hardware status changes in an English language format to all designated alarm terminals in the system.

X. The operator shall have the capability to override the operation of any RCU by command at a terminal connected to any RCU on the network.

Y. Final field programs shall be stored in a battery backed up RCU resident RAM consisting of not less than 5 MB. Field panels with less than 5 MB may not be used. The RCU shall have built-in diagnostics to display the amount of available RAM in each RCU on the network.

Z. The RCU shall be equipped with firmware resident self-diagnostics such that any sensor transmitting a signal outside of its design range (i.e. 4 to 20 mA) will be judged failed. The RCU shall be programmable to take system action such as close dampers, stop fan, etc. in response to a sensor failure.

AA. The RCU shall be listed by Underwriters Laboratories (UL) as Energy Management Equipment under UL916.

BB. A minimum of three levels of software resident password entry shall be provided at the RCU. Level 0 shall allow the operator to request and receive reports, logs, point values, and to send messages without the use of a password. Level 0 cannot command point values, display programs, or affect the system operation in any manner. Level l shall require an appropriate password of not less than six alphanumeric characters and will allow the operator to command points on/off, start/stop fans or equipment, and command analog output points to specific values. Level l shall not allow editing of the RCU program. Level 2 shall require a unique password that will allow access to the entire system and to all RCU's on the network. Level 2 permits all functions such as editing points or programs. The RCU shall automatically sign a Level l or 2 operator off from the system after a brief period of inactivity to prevent inadvertent network access. The automatic sign off feature may be disabled by command. The use of hardware password (i.e., selectable dip switches, jumpers, etc.) shall not be acceptable. Each time an operator enters a correct or incorrect password an English Language message will be automatically transmitted to all designated RCU's to announce the new system user or unsuccessful attempt.

CC. In the event that a communications trunk is severed, the RCU's shall automatically form two independent fully functional networks. On restoration of communications, a single network shall be automatically re-established.

DD. The RCU shall include all necessary software to allow the user to generate English Language advisory messages. Each message shall allow at least 45 characters. Any message shall be capable of being sent to any or all terminals on the system on operator command or automatically when alarms are annunciated. Messages shall be able to be manually or automatically generated.

EE. The RCU shall include standard and custom reports that can be generated by operator command, by event, or chronological conditions.

FF. The RCU shall have the ability and sufficient random access memory (RAM) to create unique time of day schedules.

GG. These schedules shall be capable of starting and stopping the equipment at least eight times per day if required based on time of day, day of week, month, or any combination thereof. It shall be possible to program each piece of equipment for a 365-day period.

HH. The network must be accessible through a portable full function operator's terminal for operator readout of system variables, override control, servicing, troubleshooting and adjustment of control parameters. The terminal must be fully equipped to interface with the RCU.

II. The terminal must communicate in full English language with accompanying English or SI (International System of Units) Engineering Units for inquiry, reporting, and programming purposes.

JJ. Each RCU shall be equipped with an uninterruptible power source (UPS) capable of keeping the system on line for five (5) minutes.

KK. Each RCU shall be provided with 10% spare point capacity equally divided between Analog and digital points.

2.2 STANDALONE CONTROL UNIT (RCU) SOFTWARE

A. Optimum Start Program (OS)

1. The optimum start-up time of assigned equipment shall be determined based on a software calculation which takes into consideration outdoor air conditions, space conditions, and building R factor. Any or all zones and their associated loop control shall be capable of being optimized by the optimum start program.

2. The software program shall be capable of determining the ideal start-up time in the heating and cooling system. Each zone being optimized may have its own unique set of variables, such as temperature and occupancy time.

3. The optimum start program shall control start-up of the HVAC cooling and heating equipment to achieve the target occupancy space temperature at the precise time of building occupancy.

4. By use of the keyboard, the operator shall have the ability to program the occupancy time and target temperature for each zone to be optimized.

5. A unique built-in “learning” technique allows the RCU to automatically adjust itself to the most effective time to start equipment in order to achieve the desired occupancy target temperature. Each zone being optimized has its own learning curve.

B. Custom Control Programs

1. The RCU shall provide for operator programmable custom event/response routines. A user programmable language will provide the ability for the owner to compose unique programs for handling building requirements that are not covered by the available standard programs for the system. The Custom Control Program can provide an output in response to any combination of the logical input functions AND, OR, NAND, NOR. In

addition, the Custom Control Program must also have the ability to perform mathematical operation, including ADD, SUBTRACT, SQUARE ROOT, MULTIPLY, DIVIDE, AVERAGE, MAXIMUM (highest signal select) or MINIMUM (lowest signal select) separate from or in combination with logical functions. The program must accommodate separate and unique custom control programs.

C. Direct Digital Control (DDC)

1. Direct control capability using a custom control program, manual command, or time program initiated commands shall be provided as a standard feature of this system. It shall be possible to input a sensor or group of sensors to the RCU, processing the data using the features of a Loop Control program, and output an analog control signal or set point directly to a controlled valve or damper. It shall not be necessary to provide intermediate controllers to condition the signal for the valve or damper actuator. The output signal shall be scaled in software to be compatible with industry standard control signal variable, such as 0 to 6 V dc, 4 to 20 mA and 1 to 30 PSI.

2. Integral to the Direct Digital Control capability shall be industry standard control types, such as Hysteresis (floating control), Proportional Control/direct acting, Proportional Control/reverse acting, Proportional and Integral/direct acting, Proportional and Integral/reverse acting, PID/direct acting, and PID/reverse acting. The units of control will be in engineering units, such as degrees Fahrenheit, kilowatt hours or percent relative humidity.

3. In the case of hysteresis control, dead band shall be entered in engineering units, such as degrees Fahrenheit. For proportional control, throttling range shall be specified in engineering units. For proportional and integral and PID control, reset time in quarter minutes of differential rate in units per minute shall be an operator entered constant.

4. Any software loop output in the RCU shall have the ability to control up to 64 steps of staged control or provide analog direct digital control.

5. All loop parameters shall be user definable and shall include Minimum On-Time, Minimum Off-Time, and Optimum Cycle Time for each stage of control.

D. Trend Analysis Reporting

1. Trended points may be digital inputs or outputs, analog inputs or outputs or calculated values. Time interval between samples shall be operator selected from one minute to one week. Trend logs shall be capable of providing history of facility condition and shall continue uninterrupted until the program is manually stopped or altered by an authorized operator. The trend function shall:

   a. Monitor the same point or points according to an interval and store each value.

   b. Monitor a point or points when directed by an alarm condition.

c. Store the time at which the date was taken for each.

d. Print point data according to an interval (length determined by user) or during an alarm condition.

e. Print a column header with point designation and engineering units for each point.

f. Print the time and point data information in its respective column for all values for that point.

g. Simultaneously display values not less than eight different points in individual columns coordinated by time of day for comparison.

1) Alarm Printer (Compatible with the Host Computer)

2) Keyboard

2.3 SYSTEMS INTEGRATION

A. The DDC System will monitor, control, and alarm all points being monitored and controlled.

1. A fundamental functional performance requirement is that the DDC system specified herein shall integrate seamlessly with other laboratory or vivarium control systems to the extent that the points, objects, parameters, etc. in the system.

2. This contractor shall provide a gateway to a BACnet compliant LAN provided any alternate laboratory or vivarium control vendor. This contractor shall map all objects, devices, and parameters and format graphics to represent them.

3. All specified functions requiring communications between the gateway and the LCS control network shall be accomplished using BACnet Application Services. It is the intent of this specification to require the BACnet protocol only for the point-to-point BACnet interface between the gateway provided herein and the gateway provided others. The gateways shall act as BACnet Router gateways to the individual proprietary DDC LANs. All controllers shall be mapped as virtual BACnet devices (each with a BACnet Device Object) through the gateway.

4. The following objects shall be mapped through the gateway:

a. All I/O point objects shall be mapped as Analog/Binary Input/Output Objects.

b. All adjustable set points and parameters (as designated in sequences of operation) shall be mapped as Analog/Binary Value Objects.

c. Occupancy schedules shall be mapped as Schedule Objects with holidays mapped as Calendar Objects.

5. The gateway shall allow overall system supervision, operator interface; management report generation, alarm annunciation, and communication with control units. It shall allow system operators to perform the following functions from the PCWSs.
    a. Monitor and supervise control of all points.
    b. Change control set point, timing parameters, and loop-tuning constants in all control units.
    c. Enter programmed start/stop time schedules.
    d. View and acknowledge alarms and messages.
    e. Receive, store, and display trend logs and management reports.
    f. Upload/download programs, databases, etc. as specified.
6. Gateways shall support the following BACnet compliance.
    a. BACnet Conformance Class 3.
    b. BACnet Functional Groups:
        1) Clock
        2) HHWS
        3) Event Initiation
        4) Event Response
    c. BACnet Standard Object Types:
        1) Calendar – “Description” Optional Property shall be supported
        2) Command
        3) Device – The following Optional Properties shall be supported:
            a) * Description
            b) * Location
    d. Data Link Layer Types Supported
        1) Point-to-Point EIA 232 28,800 band minimum
        2) Point-to-Point Modem 28,800 band minimum
    e. ANSI X3.4 character set for BACnet communications.
    f. Segmented Requests and Responses with a minimum Window size of 1.
    g. Half-router shall be supported for point-to-point sessions.

7. Real and/or Virtual BACnet devices representing LCS controllers shall support the following BACnet Objects. The "Description" Optional Properties shall be supported for each object:

   a. Analog Input

   b. Analog Output

   c. Analog Value – "Present Value"

   d. Binary Input

   e. Binary Output

   f. Binary Value – "Present Value"

2.4 BUILDING ENGINEERS WORKSTATION

A. Provide one workstation computer and workstation software installed to provide an interface for monitoring, troubleshooting, and making adjustments to the program or operating parameters of the DDC System from a central location. Locate systems per section 230900 1.3E. The workstation shall be capable of accessing all controllers, including ASCs, in the DDC System and integrated system data. DDC System shall routinely operate stand-alone on a continuous basis without connection to the workstation. Information at the workstation is not required for day to day operations of the Direct Digital Controllers. Provide UPS modules for both work stations.

B. Hardware

1. All workstation computer equipment and peripherals shall be recommended by the DDC system manufacturer. The workstation shall be configured to operate according to the DDC System manufacturer's specifications. Workstation hardware shall be configured to allow operation of software, uploading and downloading of programs, and creation of graphics. At a minimum the workstation hardware shall consist of the following:

   a. Computer: The computer shall be DOS and Windows NT compatible and shall not have less than Intel Pentium4 processor, running at 2.8GHZ speed, 120.0 gigabyte hard drive, 512 megabyte RAM, 2 serial and 1 parallel port, super VGA video card, and 17 inch monitor with a resolution of 740 X 1024 and 0.28 dpi, and a 1.4 megabyte 3½ inch floppy drive.

   b. Mouse.

   c. Fax/Modem 14.4/33.6.

   d. Printer; laser jet printer with resolution 600 dpi X 600 dpi.

e. 110 volt terminal strip with surge protection.

f. Provide UPS modules.

C. Software

1. Workstation software shall be Siemens Apogee. Workstation software shall be resident in the workstation computer. Workstation software shall permit monitoring and troubleshooting of the DDC System. Workstation software permits modification of the controller database and control programs. Operations shall be menu selected. Menu selections shall be made with a mouse.

   a. Menu System: Menu system shall allow an operator to select a particular function or access a particular screen through successive menu penetration.

   b. Controller Database Modification: The workstation software shall be an interface for performing capabilities specified in paragraph entitled “DDC Software” and available through direct connection of a computer to a digital controller. Database modification shall require only that an operator “fill in the blank” for that parameter on a screen requesting the information in plain language. Database modification shall be automatically downloaded to the appropriate controllers at operator request.

   c. Program modification: For systems using a line-by-line programming language, provide an off-line text editor, similar to a BASIC program editor, permitting modification of controller resident control programs. For systems using blocks together to create new programs or modify existing programs. Program modifications shall be automatically downloaded to the appropriate controllers at operator request.

D. Graphic-Based Software

1. Graphic-based software shall provide graphical representation of the building, the buildings mechanical systems, and the DDC System. The current value and point name of every IO point shall be shown on at least one graphic and in its appropriate physical location relative to building and mechanical systems.

   a. Graphics shall closely follow the style of the control drawings in representing mechanical systems, sensors, controlled devices, and point names.

   b. Graphic Title: Graphics shall have an identifying title visible when the graphic is being viewed.

   c. Dynamic Update: When the workstation is on-line with the control system, point data shall update dynamically on the graphic images.

d. Graphic Penetration: Provide graphic penetration. For systems without graphic penetration, provide menu penetration for selection of individual graphics to give the same hierarchical affect provided by graphic penetration.

e. Graphic types: Graphic based software shall have graphics of the building exterior, building section, floor plans, and mechanical systems. Provide the following graphics.

1) Building Exterior Graphic: Show exterior architecture, major landmarks, and building number.

2) Building Section Graphic: Show stacked floors in section graphic with appropriate floor name on each floor.

3) Floor Plan Graphics: Provide a single graphic for each floor, unless the graphic will contain more information than can be reasonably shown on a single graphic. Each heating or cooling zone within a floor plan shall have a zone name and its current temperature displayed within the zone outline. Show each controlled variable in the zone. Provide visual indication for each point that is in alarm.

4) Mechanical System Graphics: Provide two-dimensional drawings to symbolized mechanical equipment; do not use line drawings. Show controlled or sensed mechanical equipment. Each graphic shall consist of a single mechanical system; examples are a graphic for an Air Handling Unit, a graphic for a VAV box, a heating water system, and a graphic for a chiller system. Place sensors and controlled devices associated with mechanical equipment in their appropriate locations. Place point name and point value adjacent to sensor or controlled device. Provide visual indication of each point in alarm condition, such as zone temperature, associated with mechanical system shall be shown on the graphic. Point values shall update dynamically on the graphic.

f. Graphic Editing: Full capacity as afforded by a draw software package shall be included for operator editing of graphics. Graphics may be created, deleted, and modified, and text added. Provide capability to store graphic symbols in a symbol directory and incorporate these symbols into graphics. A minimum of sixteen colors shall be available.

g. Dynamic Point Editing: Provide full editing capability for deleting, adding, and modifying dynamic points on graphics.

h. Trending: Trend data shall be displayed graphically with control variable and process variable plotted as functions of time on the same chart. Graphic display of trend data shall be a capability internal to the workstation software and not a capability resulting from download of trend data into a third-party spreadsheet program, such as Lotus, unless such transfer is automatic and transparent to the

operator, and the third-party software is included with the workstation software package. At the operator's discretion trend data shall be plotted in real time.

E. Maintenance Personnel Interface Tools

1. Provide one (1) notebook computer for field communication with the digital controllers. In addition to changing set points, and making operations changes, field personnel shall be able to upload and download programs with the notebook computer. Notebook computers shall have the same hardware, except standard notebook-size SVGA screen in lieu of 17-inch screen with the following additional requirements.

a. Internal battery operation; for a minimum of three (3) hours of operation.

b. Serial interface port to communicate with the digital controller.

c. Software: Same as workstation computer.

d. Carrying case.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components and appurtenances in accordance with the manufacturer's recommendations and as shown on the Instrumentation Drawings. Provide all labor, materials, tools, appliances, equipment, devices, conduit, and wiring for a complete operable systems as shown on the drawings and specified herein. Installation of electrical wiring and devices shall be in accordance with Division 26. Provide power disconnects at all DDCP panels. Identify control panel power circuit at DDCP panel.

B. Provide necessary interlock wiring.

C. Provide all electrical work in accordance with Division 26 of the Specifications.

D. If a field mounted device or piece of equipment requires 120 V ac service and is mounted at a different location from the 120 V ac power source supplied under Division 26, provide extensions to the power wiring, including conduit, junction boxes, and other hardware, all meeting the requirements of Division 26.

E. If there is any question as to the validity of any control, alarm, and/or interlock wiring, verify to the Government's Representative that field wiring has been done in accordance with Division

26 and has been properly connected to the appropriate device(s) as shown on the Contract Drawings.

F. Operators for all terminal units will be provided under this Section.

G. Power wiring to control panels will be provided in accordance with Division 26.

H. Refer to specification section 230593 for coordination during testing and balancing of systems.

I. Provide complete data on requirements of equipment and system to other trades when required.

J. Provide all necessary cooperation and coordination with the Division 26 Contractor such that all power and ground wiring is provided in strict accordance with the DDC equipment manufacturer’s recommendations. The DDC system supplier/installer shall make all final electrical connections to the DDC system equipment.

K. At all penetrations through designated vapor retardant walls (See Architectural Drawings), provide patching and sealant with FDA approved silicone caulk. Also provide air and vapor tight sealing of shielded air probes (SAPs) with FDA approved silicone caulk.

3.2 TRAINING

A. General: The controls contractor shall conduct training courses for designated personnel in the maintenance and operation of the CCMS as specified. The training shall be oriented to the specific system being installed under this contract.

B. Training manuals shall be provided for each trainee for the Operator's Training I course and Operator's Training II courses with additional copies provided for archival at the project site. The manuals shall include an agenda, defined objectives for each lesson, and a detailed description of the subject matter for each lesson. The controls contractor is responsible for furnishing all audiovisual equipment and all other training materials and supplies. Where the controls contractor presents portions of the course material by audiovisuals, copies of those audiovisuals shall be delivered to the Owner either as a part of the printed training manuals or on the same media as that used during the training sessions, in the same quantity as specified for instruction, including two 15-minute breaks and excluding lunch time, Monday through Friday, during the normal first shift in effect at the training facility.

C. For Operator's Training II the controls contractor shall furnish two (2) sets of applicable reference materials, to be kept on site for Owner’s usage.

D. For the Maintenance Personnel Training the control contractor control contractor shall furnish two (2) additional sets of as-built drawings on the Distributive Digital Control Systems, valve schedules, point log information, and programs.

E. For guidance in planning the required instruction, the controls contractor should assume that attendees will have a high school education or equivalent, and are familiar with HVAC systems. Notification of any planned training shall be given to the Owner at least 30 days prior to the training.

F. Operator's Training I: The first course shall be taught off-site for a period of 2 consecutive training days prior to the controls contractor field testing activity. This course shall be an orientation to Stand Alone Control Units. Two (2) groups of four (4) will attend this course. Upon completion of this course, each student, using appropriate documentation, shall be tested for proficiency. The questions on the exam shall test the students’ ability to 1) perform elementary operations, 2) describe the general hardware architecture and functionality of the Stand Alone Control Units, and 3) understand the general system architecture. The test questions shall include but not be limited to:

1. Fill-in-the-blanks form for RCU hardware components.
2. Fill-in-the-blanks form for general system architecture.
3. Essay questions relating to "PPCL" and "Point Data Base".
4. Essay questions relating to the procedures for generating reports and logs.
5. Match definitions with DDC nomenclature.
6. True/false questions related to system operations.

G. No later than two weeks after the completion of the course, both the test scores and a description of suggested corrective action shall be submitted to the Section Chiefs for each student.

H. Operator's Training II: The second course shall be taught while the field-testing is in progress for a total of 48 hours of instruction. Two (2) groups of four (4) shall receive individual instruction in time blocks of 4 hours. The schedule of instruction shall allow for each group to receive individual instruction for a 4-hour period in the morning (or afternoon) of the same weekday for 6 consecutive weeks. The controls contractor shall schedule his activities during this period so that the specified amount of time will be available during the field testing for

instructing the students. The course shall consist of “hands-on” training under the constant monitoring of the instructor. The sections for these courses shall include but not be limited to:

I. HOST COMPUTER:

1. Acronyms
2. Operator Console
    a. Central Processing Unit
    b. Field Interface Systems
    c. Points General Data
    d. Test Block
    e. Point Entry
    f. Point Entry Check Out Procedure
    g. System Reports Commands
    h. Front End Processor Commands
    i. Point Control Commands
    j. Sequential Point Commanding
    k. Message Processing
    l. Time of Day Scheduling
    m. Historical Data File
    n. RCU PROGRAMMING:
    o. Point Types
3. Databases
4. RCU Configurations
5. RCU Hardware and Terminal Setup
6. Point Database
7. PPCL
8. Sample Programs
    a. Typical Air Handling Unit
    b. Pump Sequencing

J. At the end of each day the controls contractor shall record the student's level of skill based on the number of sections passed. This record, the tests, and the test scores shall be available to the section chiefs upon request. No later than two weeks after the completion of the 6 week training session the contractor shall submit to the section chief a record of each students level of skill based on the number of sections passed. The controls contractor shall also submit a description of the required skills not yet obtained by each student, and recommended corrective action. The controls contractor shall also submit a summary of recommended access limitation for each student.

K. The Owner will use the recommendations of the instructor to determine the appropriate password to be issued to the student commensurate with each student's acquired skills at the beginning of each of these individual training sessions.

L. Maintenance Personnel Training: The maintenance course shall be taught at the project site after completion of the Endurance Test for a period of 2 training days. Four to eight maintenance personnel will attend the course. The training shall include:

1. Physical layout of each piece of hardware.
2. Troubleshooting and diagnostics procedures.
3. Repair instructions.
4. Preventive maintenance procedures and schedules.
5. Calibration procedures.
    a. Upon completion of this course, each student shall be tested for proficiency. The questions on the exam shall test the students' ability to 1) perform elementary maintenance operations, 2) describe the general hardware architecture and functionality of the Stand Alone Control Units, and 3) understand the general system architecture. The test questions shall include but not be limited to:
6. Fill-in-the-blanks form for RCU hardware components.
7. Fill-in-the-blanks form for general system architecture.
8. Essay response to questions related to analyzing problems.
9. Match definitions with DDC nomenclature.
10. True/false questions related to system operations.

M. Conform to the training requirements outlined in the Section 230800. Specifically provide content related to this section for the Training Plan, and provide the persistent documentation of the course electronically. Provide the audio-visual equipment to present the training per that section.

N. All required programming and start-up services shall be provided by the Control Contractor to effect the control sequence described in the specification. Start-up services shall include detailed instructions and training to all campus service personnel on the operations, maintenance, and troubleshooting of the CCMS. Instruction and training sessions shall be coordinated with and by in addition to those specified. Coordination with the Commissioning process: the start up, training, and documentation shall be coordinated with the commissioning process and protocols outlined in Section 230800. Attention is called to the requirement for development of start up tests and checklists in the electronic format specified, documentation of the start up and checkout activities via that electronic forum, submittal of operation and maintenance data electronically per those requirements, and approval of functional performance tests related to equipment of this section.

PART 4 - TEMPERATURE CONTROL SEQUENCES (see drawings)

1. At the start of each program provide a “Plain English” explanation of the sequence of operation for the equipment controlled.

END OF SECTION 230900

SECTION 230910 – AUTOMATIC TEMPERATURE CONTROL INSTRUMENTATION

PART 1 - GENERAL RELATED DOCUMENTS

1.1 RELATED DOCUMENTS

A. Drawings and General Provisions of the Contract, including General and Supplementary Conditions and other Division 23 Specification Sections, apply to this section.

B. Installation, application and start up instructions shall be submitted within 30 days of shop drawing approval to facilitate the commissioning process outlined in Section 230800.

C. Coordination with the Commissioning process: the start up, training, and documentation shall be coordinated with the commissioning process and protocols outlined in Section 230800 Attention is called to the requirement for development of start up tests and checklists in the electronic format specified, documentation of the start up and checkout activities via that electronic forum, submittal of operation and maintenance data electronically per those requirements, and approval of functional performance tests related to equipment of this section.

1.2 DESCRIPTION OF WORK

A. In general, the Contractor or his subcontractor designee shall furnish, install, and provide documentation including equipment catalogs, calibrate, perform all testing, place in service, and supply all spare parts and associated labor for the first year of operation for all instrumentation and controls required for all mechanical and electrical equipment and systems provided. This section specifies the minimum requirements for all instrumentation and control equipment, and shall be fully coordinated and integrated with Section 230900.

B. Provide instrumentation and control equipment for the Distributive Digital Control and Monitoring System (DDC) as specified herein and as shown on the contract drawings to support Section 230900. All digital input (DI) contacts shall be normally-closed (NC) in their normal (non-alarm) state. All analog variable transmitters shall provide 4 to 20 mA signals to analog input (AI) points.

C. Furnish automatic dampers to the Division 23 Contractor for installation.

D. Furnish automatic control valves to the Division 23 Contractor for installation.

E. Furnish airflow measuring devices for installation by supply fan manufacturer to ensure performance testing with air monitors.

F. Provide manual on/off switches with indicating pilot lights, fan relays and wiring to all building fans. Switches shall be located in the fire control room. Switches shall override all system safeties

G. The control contractor in conjunction with the energy recovery wheel vendor may provide and install their controls in lieu of the manufacturer's controls to ensure coordination and proper placement for best system control.

1.3 RELATED WORK SPECIFIED ELSEWHERE

A. Distributive Digital Control and Monitoring (DDC) - Section 230900

B. Electrical Work - See Division 26.

1.4 SUBMITTALS

A. Submit product data to the Engineer for approval prior to installation. Submittals shall show complete engineering data and shall meet or exceed all details of each product's specification specified herein.

B. Furnish name, address, and telephone number of Control Contractor's Field Representative.

C. An equipment cover sheet shall be marked for clear identification of the following information (except as noted):

1. Project name and phase (as applicable).
2. Contractor's name.
3. Date of submission.
4. Page and paragraph number of the contract specifications to which particular equipment applies (MUST BE WRITTEN ON EACH DATA SHEET).
5. Indication of the system on which the device is utilized.

D. Furnish operation and maintenance manuals in accordance with Division 1. Manuals shall be bound in a hardcover oversized binder, with space for additional information and plastic-printed index tabs identifying the major sections. Manuals shall include:

1. Installation instructions.
2. Principles of operation and calibration instructions.
3. Set-up and operating instructions.
4. Routine preventive maintenance procedures, and diagnostic and corrective troubleshooting procedures.

E. Submit samples if requested.

1.5 REFERENCE CODES AND STANDARDS

A. Comply with the following in accordance with Division 1.

1. Air Moving Control Association (AMCA)

500	Test methods for louvers, dampers, and shutters.

2. American National Standards Institute (ANSI)

B16.22	Wrought copper and copper alloy solder-joint pressure fittings.
B16.104	Quality control standard for control valve seat leakage.

3. American Society for Testing and Materials (ASTM)

B88	Specification for seamless copper water tube.
D635	Test method for rate of burning and/or extent and time of burning of self-supporting plastics in a horizontal position.
D1693	Test method for environmental stress-cracking of ethylene plastics.

4. ANSI/American Society of Mechanical Engineers (ANSI/ASME)

5. Boiler and pressure vessel code, Section VIII - Pressure Vessels.

6. ANSI/Instrument Society of America (ANSI/ISA)

S7.3 Quality standard for instrument air.

S75.0 Uniform face-to-face dimensions for flanged globe style control valve bodies.

S75.04 Face-to-face dimensions of flangeless control valve.

7. Underwriters Laboratories, Inc. (UL)

94 Tests for flammability of plastic materials for parts in devices and appliances.

5555 Leakage-rated dampers for use in Smoke Control Systems.

8. IBC International Building Code

9. IMC International Mechanical Code

10. National Fire Protection Association (NFPA)

1.6 DESIGN CRITERIA

A. The instrumentation and control equipment shall be designed for complete integration with the control system specified in Section 230900.

B. The instrumentation and control equipment shall be complete and fully operational, meeting all performance requirements, and shall be completely integrated with Section 230900 to provide a totally functional system.

C. Control power shall not exceed 120 V ac, unless otherwise shown.

PART 2 - PRODUCTS

2.1 GENERAL

For each product, provide to the contracting officer complete instruction manuals in accordance with Division 1 describing exact installation, calibration, operating, and maintenance procedures, including recommended spare parts.

2.2 AUTOMATIC DAMPERS - HEAVY-DUTY (HD)

A. Dampers shall be modulating, double-acting, opposed-blade or parallel-blade type as shown, designed and tested in accordance with AMCA 500. Obtain and verify the location, size and pressure rating of each damper from the Sheet Metal Contractor prior to fabrication and delivery. Verify the layout of equipment and ductwork before dampers are fabricated. Pressure drop shall not exceed 0.03 IWG static pressure at 1000 FPM in the fully open position.

B. Dampers shall be constructed of extruded aluminum or at least No. 14 gauge steel, with each blade being not more than 8 inches wide; damper frame channel shall be at least 8 inches deep. Each blade end shall have a 0.75 inches stainless steel or plated steel shaft rotating in self-lubricating bearings mounted in damper channel frame. Blades mounted vertically shall be supported by thrust bearings. Control shaft shall be at least 0.5 inch diameter.

C. Flat-steel damper blades shall be made rigid by folding the edges. Blades shall have interlocking edges and shall be provided with EPDM or neoprene compressible seals at point of contact. Foam seals are not acceptable. Provide dampers with operators having sufficient power to limit leakage to the rate specified.

D. Each damper shall be assembled in the manufacturer’s shop as a complete unit. Dampers, when closed, shall be guaranteed by the manufacturer not to leak in excess of 2 CFM/SF at 4 IWG static pressure. Provide dampers with operators having sufficient power to limit leakage to the rate specified.

E. Damper seals shall be suitable for an operating range extending from minus 82 degrees F at the lower end to 250 degrees F at the upper end.

F. Operating links (connecting rods) transmitting motion from damper motors to dampers shall withstand a load equal to at least twice the maximum damper operating force without deflection. Lengths shall be adjustable. Links shall be steel and zinc-coated or cadmium-

plated. Working parts of joints (e.g. clevises, and ball and socket joints) shall be brass, bonze or stainless steel. Operating links which connect two or more separate damper assemblies to a single operator are not acceptable. Bearings and linkages shall be accessible for maintenance and repair.

G. A complete damper assembly shall have blades no longer than 4 feet and no higher than 6 feet. Where greater length or height is required, the assembly shall be made from a combination of sections. Dampers shall be sized for the scheduled air velocity and pressure classification.

H. All automatic dampers installed in stainless steel ducts shall be 100% stainless steel construction, with identical steel gauges and characteristics as specified herein.

I. Automatic dampers shall be Type CD-80AF1 by Ruskin Manufacturing Company or approved equal. Dampers shall withstand up to 10”WG system shut off pressure.

J. Factory built air-handling unit manufacturer shall provide unit isolation dampers, this section shall provide all other automatic isolation and control dampers.

2.3 ELECTRICAL ACTUATORS

A. Electronic Damper Actuators

1. Electronic damper actuators shall be direct shaft mount.

2. Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized based on actuator manufacturer’s recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequence of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

3. Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall e wired back to a terminal strip in the control panel for trouble-shooting purposes.

4. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and the UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be heard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operation as “quick acting,” shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

B. Electronic Valve Actuators

1. Electronic valve actuators shall be manufactured by the valve manufacturer.

2. Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to he actuator.

3. Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized based on valve manufacturer’s recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

4. Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall e 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal of each valve actuator (except terminal valves shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

5. Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

2.4 AUTOMATIC CONTROL VALVES

A. Automatic control valves shall have bodies, discs, stems, and stuffing boxes designed for ANIS 125/150 pound service and ANSI Class IV or V leakage. Valve bodies sized 3 inches and smaller shall be cast iron or carbon steel. Valves with 4-inch bodies or larger shall have carbon steel bodies. (No cast iron valves will be allowed for flammable service). Valves 2-1/2 inches and larger shall be provided with flanged end connections. Valves less than 2-1/2 inches shall have threaded end connections. Coordinate all end connections with the Division 23 Contractor. Provide visible position indicators on all automatic control valves.

B. All internal trim of valves controlling steam or water hotter than 210 degrees F shall be stainless steel. All non-metallic parts of hot water or steam control valves (such as packing glands, gaskets, and other valve trim) shall be suitable for am minimum continuous operating temperature of 450 degrees F.

C. Valves shall provide tight shut-off in the closed position in accordance with ANSI requirements specified above. Two-way modulation valves shall be post guided plug type, or the equivalent, to provide equal percentage control of water and linear control of steam. Three-way valves shall provide linear flow control with constant total flow throughout full plug travel.

D. Two-way, single-seated modulating valves controlling duct-mounted water coils shall pass the quantity of water shown on the Division 23 Schedules, with pressure drop through the valve at this flow in accordance with Table D-2 below. All other valves shall be sized for pressure equal to the allowable pressure head drop according to the particular pump curve.

Table D-2

COIL TYPE (Per Division 23 Schedule)	COIL DESIGN PRESSURE DROP (Feet of Head)	VALVE DESIGN PRESSURE DROP (Feet of Head)
Chilled Water Coils	See Equipment Schedules on HVAC Drawings	12
Heating Water Coils		
Glycol Water Coils		

E. Valves in single steam control valve installations shall not be larger than 2 inches in size; where larger valves are required, multiple valve stations shall be installed. Valves in multiple valve station shall not exceed 4 iches in size; where practical, two-valve station shall be sized so that load is split 1/3 and 2/3 between the valves; three-valve stations shall be sized so that load is split 1/6, 1/3, and 1/2.

F. Each steam valve shall be sized so that the pressure drop across the valve at maximum flow will be no more than 50% of the inlet absolute pressure (psia), and between 50-80% of the inlet gauge pressure.

G. All duct or unit water coils with copper connections and copper tubing supply line shall be provided with a control valve with either flare-type or solder-type ends. Furnish flare nuts for each valve for installation in accordance with Section 230050.

H. Approved Manufacturers – Fisher Controls, Inc., Warren Controls and Hammel, Dahl, & Jamesbury.

I. Valves on compressible fluid service shall not have noise in excess of 85 dBA at 3 feet outward or 3 feet downstream of the valve centerline for continuously operating valves. Where specified insulation is recommended by the vendor, the expected noise reduction shall be stated.

J. Valve body fluid velocities shall be limited to 40 fps as liquid and 0.3 mach as flashed steam and water. Trim sizes may be reduced when pipe size or rangeability are limited. Chrome-moly body material is required for steam-flashing service.

K. Main chilled water control valve V- CHS-1 shall be equal to Masoneilan Varimax 3000 series rotary globe valve with adjustable travel and torque actuator.

a. ANSI class 300, carbon steel body,316 SS plug, rotary globe body

b. Standard plug trim, eccentrically rotating

c. 316 SS with PTFE-Ni insert seat

d. 7-25 psi actuator spring range

e. 316 SS shaft

f. flow characteristic-linear

2.5 FIELD EQUIPMENT PANELS (FEP)

A. Panels shall be steel enclosures at least 24 inches wide, 12 inches high, and a minimum of 8 inches deep, with locking steel door. Total panel, including removable backplate for equipment mounting, shall be made rust-resistant and painted with epoxy enamel. All door locks shall operate from a common key.

B. Each item of terminal equipment (such as dampers and valves) controlled from panel-mounted devices shall be provided with a flush-mounted panel-door air gauge at least 2 inches in diameter.

C. Provide separate receiver gauges for pneumatic control signal lines. Gauges shall be a minimum of 4 inches in diameter + 1% full-scale accuracy.

D. All gauges and control devices of the fan system shall be placed in one group for each system on a steel-hinged control panel door so that complete operation of all equipment can be checked simultaneously at the panel. All piping shall be inside the panel.

E. All manually operated switches, gradual switches, and pilot lights shall be door mounted.

F. Provide lamacoid nameplates, with 1/8 inch engraved black letters on white background, permanently secured in place describing the panel device. Clearly identify items as to function, switch position, temperature, location, and type of temperature controller. The use of plastic tape with embossed letters or the painting of lettering directly on the surface of the nameplate will not be acceptable.

G. All other control devices shall be located inside the panel, and mounted to allow sufficient space for both interconnecting pneumatic tubing and wiring. Interior panel tubing and wiring shall be arranged in a systematic, orderly manner and brought to terminal blocks for connection of field wiring. Low-voltage and line-voltage terminals shall be isolated from one another.

H. Furnish record drawings in a plastic pocket affixed inside the panel to show all systems and devices controlled from the panel.

I. All panels shall meet the National Electrical Manufacturers Association (NEMA) requirements for their intended use and location as specified in their latest Standard ICS 1-110 entitled “Enclosures for Non-Hazardous Locations”, unless otherwise noted or upgraded.

2.6 THERMOMETERS AND AIR PRESSURE GAUGES

A. Dial Thermometers:

1. Dial thermometers shall be direct-reading and shall have a temperature range as indicated on the Instrumentation Drawings. Each unit shall be designed to read air temperature in storage tanks or pipes as shown on the Instrumentation Drawings.

2. Dial thermometers shall measure temperature by use of liquid-filled bulbs (no mercury) and Bourdon-tube sensing elements.

3. All internal components shall be brass or other non-ferrous material and shall be enclosed in a chrome-plated, hard-drawn, brass enclosure. Dial face shall have unbreakable acrylic plastic lens. Dial face shall be no less than 4 inch in diameter.

4. Dial thermometers shall have a range of 40 degrees F to 110 degrees F. A maximum safe temperature range at least 30 degrees F above the manufacturer's indicated range shall be provided.

5. Dial thermometers for measuring air temperature shall be duct-mounted and shall have approximately 3.1 meters of capillary tubing with flexible braided metal covering. Sensing bulb shall be a coiled element approximately 10 inches in length, and shall be capable of being uncoiled for at least 6 feet of averaging temperature. Bulb shall be installed as an averaging element where indicated on the Instrumentation Drawings. Sensing element shall extend into the center of the ductwork cross-section or as far into the ductwork cross-section as the capillary will allow. Support and fasten the capillary and element throughout the ductwork section.

6. All dial thermometers shall have an accuracy of +1.0% of scale throughout the range of measured temperature.

7. Manufacturer – Trerice or approved equal by the Contracting Officer.

B. Air Pressure Gauges:

1. Gauges shall be manufacturer's standard product and shall be a minimum of 1 inch in diameter for stem-mounted units.

2. Provide stem-mounted air pressure gauges on the air supply line to and from all thermostats, final control elements, and pneumatic field devices so that the operation of each piece of controlled equipment can be checked.

2.7 TEMPERATURE SENSORS (ELECTRONIC)

A. General:

1. Temperature sensor shall include the following:

   a. Temperature Element and Probe

   b. Temperature Transmitter

   c. Space thermostats shall be equal to Siemens series 2000

2. Provide the temperature sensor assembly as a single unit.

3. Furnish thermowells to the Division 23 Mechanical Contractor for installation as required by the Contract Documents.

B. Temperature Element and Probe:

1. Unit shall be a three-wire or four-wire ungrounded RTD-type element housed in a general-purpose temperature probe.

2. Temperature probe shall be spring loaded to ensure positive connection between thermowell and probe tip. Provide a connector head with probe for transmitter housing.

3. Probe sheath shall be Type 316 stainless steel and 6.4 mm (maximum) in diameter.

4. Probe immersion length shall be factory matched and tested for insertion into thermowell specified below.

5. Probe shall have a 3 inch lagging extension neck.

6. Temperature element shall be 100 ohm platinum RTD with a temperature coefficient of 0.00385 per DIN 43760 (ohms/ohm/°C).

C. Thermowell:

1. Thermowell shall be a lagging extension type well with a threaded connection to piping. If process pressure is above 300 psig or piping contains steam or some other similarly dangerous fluid, then the thermowell shall be the socket-welded or weld-in type.

2. Process connection size shall be 3/4 inch NPT, or weldolet for piping which requires welded connections.

3. Thermowell shall have a 0.3 inch inside diameter and an insertion length into pipe of proper distance to adequately measure the process and to meet end-to-end accuracy specifications.

4. Thermowell shall have a 2 inch lagging extension neck.

5. Thermowell material shall be either the same material as the corresponding pipe or a compatible material with the pipe, especially when welding into pipe.

6. Furnish thermowell with a threaded brass plug and chain.

7. Top section shall be provided with wrench flats.

8. Socket welded and threaded thermowells shall have a tip thickness of 3/16 inch minimum and 1/4 inch maximum. Weld-in thermowells shall have a tip thickness of 1/4 inch minimum and a 5/16 inch maximum.

D. Temperature Transmitter:

1. Temperature transmitter shall be a two-wire type current transmitting device and, if readily accessible, suitable for mounting inside the temperature probe connector head such that the probe and transmitter are contained in a single assembly. If not accessible location separate from the probe to facilitate calibration and maintenance.

2. Transmitter shall interface to the RTD probe with a three-wire or four-wire connection and transmit a two-wire, 4 to 20 mA signal output from 100 ohm RTD.

3. Transmitter shall have built in circuit protection against reverse polarity and supply voltage transients.

4. Transmitter shall have a minimum range of 32 degrees F to 100 degrees F and a maximum range of minus 0 degrees F to 250 degrees F for HVAC applications (air and water). Other ranges shall be provided for the application but in no instance shall the range exceed 150% of maximum expected temperatures.

5. Transmitter accuracy shall be + 0.1% over specified range.

E. Manuals:

1. Provide complete instruction manuals describing step-by-step procedures for the installation, operation, and maintenance of the device.

F. Manufacturers (Probe):

1. Yellow Springs Instrument Company, Inc.

2. Weed Instrument Company, Inc.

3. ITT Barton Process Instruments and Controls.

4. Thermo-Electron Company.

5. Rosemount.

6. RDF.

7. Leeds and Northrup.

G. Manufactures (Transmitter):

1. Bailey Controls.

2. Rosemount.

3. Foxboro.

4. Fischer & Porter.

5. Taylor Instrument Company.

2.8 TEMPERATURE SENSORS (ELECTRONIC) - AVERAGING TYPE

A. General:

1. Average temperature transmitter assembly shall consist of the following:
    a. Temperature Element.
    b. Temperature Transmitter.
    c. No more than 3SF of coil per foot of senor
2. Provide average temperature transmitter assembly as a single unit.
3. Units shall be either FM-approved explosion proof or intrinsically safe where indicated in Part 3 Execution of this specification.

B. Temperature Element (Averaging):

1. Unit shall be a three-wire RTD element, averaging type, housed in a bendable sheath.
2. The element shall provide a true averaging resistance transducer and not multiple resistance elements.

C. Temperature Transmitter (Where Shown):

1. The averaging temperature transmitter shall be compatible with the manufacturer's element being provided. Transmitter device shall be suitable for mounting integral with the average temperature element head, such that the element and transmitter are contained in a single assembly.
2. The transmitter shall transmit a linear current signal proportional to the average temperature measured by the temperature element.
3. Transmitter shall have built in circuit protection against reverse polarity and supply voltage transients.
4. Temperature range shall be suitable for the application.
5. Transmitter and probe combined accuracy shall be + 0.2% over the calibrated specified range.

D. Manufacturers:

1. Minco Temptran Series.
2. Hy-Cal Engineering.

3. Comax Corporation.

2.9 RELATIVE HUMIDITY SENSOR ASSEMBLY

A. General:

1. The relative humidity sensor shall consist of the following:
   a. Relative Humidity Sensor
   b. Relative Humidity Transmitter.
   c. Humidity sensors for vivarium area shall be equal to Vaisala model HMD 60
2. Provide the relative humidity transmitter assembly as a single unit.
3. Units shall have three separate mounting arrangements; wall, duct, and outside, as required by the Contract Documents, and flush-type aspirating box when indicated.
4. Units shall be either intrinsically safe or FM approved explosion-proof where indicated in Part 3 Execution of this specification.

B. Relative Humidity Sensor:

1. The sensor shall meet the following requirements:

a.	Humidity Range:	0 - 100%. Temperature compensated
b.	Total Overall Accuracy:	0 - 95%, $\pm$ 2.0%; any 25% Rh span $\pm$ 1.0 RH.
c.	Time Response:	1-minute nominal in air at 3 psi.
d.	Operating Temperature:	-40°F to +150°F.
e.	Repeatability:	$\pm$ 0.5% RH.

2. For duct mounting, sensor shall have a 3/8 inch diameter metal body, with protective sheath and length to be 12 inches for each 4 ft^2 of duct area.
3. Units shall be completely washable (provide cap where wash down is destructive to sensor).
4. Sensor housing shall be splash protective and dust resistant.

C. Relative Humidity Transmitter

1. The transmitter shall transmit a linear current signal proportional to the relative humidity measured by the relative humidity sensor.

2. The transmitter shall meet the following requirements.

   a. Output Current: 4 to 20 mA dc into 500 ohms (minimum at 24 V dc supply).

   b. Operating Temperature: 0°C to 70°C.

   c. Zero and Span Adjustment: ± 5% of span.

   d. Polarity Protection: Diode.

3. The transmitter shall be housed in a duct or wall-mounted in a weatherproof enclosure in accordance with specific requirements.

D. Manufacturers - The relative humidity transmitter shall be manufactured by:

1. Hy-Cal Engineering.
2. Beckman Instruments, Inc.
3. General Eastern, Inc.
4. Rotronic Instrument Corporation.
5. Vaisals, Inc.

2.10 ELECTRICAL SAFETY THERMOSTATS (FREEZESTATS)

A. Safety thermostats (TS) shall have an extended 20 feet element to sense the temperature of the air entering the cooling coil. Thermostats shall respond to the coldest incremental maximum 12 inches segment.

B. If temperature falls below the designated set point, the thermostat shall stop the fan. Thermostats shall require manual reset.

C. Provide thermostats with identifying tags designed to prevent accidental removal.

D. Provide one (1) freezestat for each 20 ft^2 of coil face area.

E. On units with energy recovery wheels, freezstats will be configured to avoid stratification off of the energy recovery wheel.

2.11 CONTROL RELAYS

A. Control relays shall be of the electro-mechanical type with coils for 120 V ac 60 Hz, and shall have contacts to handle the required load without contact bounce.

B. Relays shall have normally-open (NO) and/or normally-closed (NC) contacts, with the number of poles required to perform the indicated functions.

2.12 ELECTRO-PNEUMATIC SOLENOID VALVES (SV)

A. Electro-pneumatic solenoid valve shall be constructed for operation at a maximum of 480 V ac. Solenoid valve shall be rated for 5 amps minimum.

B. Air valves, piloted by solenoid valves, shall be provided where EPs will not meet the capacity requirements of the load.

2.13 PRESSURE DIFFERENTIAL INDICATING SWITCHES (PDIS), INDICATORS (PDI), AND SWITCHES (PDS)

A. Pressure differential indicating switches (PDIS) shall consist of two parts: the gauge and photoelectric sensor, approximately 127 mm in diameter X 76 mm high; and the electronic amplifier and remote-mounted relay, approximately 127 mm in diameter X 130 mm high, with cable length as required. Set points and zero adjustment shall be tamper proof.

B. Load relays shall be DPDT for each set point, 10 amps resistive, 120 V ac, 50 or 60 Hz.

C. In lieu of the above, the Contractor may use a pressure differential switch (PDS) and indicator (PDI) combination.

D. Manufacturer - Dwyer Series 3000 (PDIS), Dwyer Series 2000 (PDI), Dwyer Series 1627 (PDS) or approved equal by the Contracting Officer.

E. Current sensors may be used for fans at contractor’s option. Current sensors shall be equal to Veris Industries model Hawkeye 904. Sensors shall be for VFD application with ability to store in memory normal operations at various frequencies. Sensor must be able to detect belt loss or coupling shear.

2.14 LIQUID DIFFERENTIAL INDICATING SWITCHES

A. Liquid differential pressure switches shall be piped in parallel with a system water circuit for indication of flow.

B. Switches shall operate from a dacron reinforced neoprene slack diaphragm corrosion resistant stainless steel diaphragm, or copper diaphragm capable of being adjusted through the total working range.

C. Switches shall withstand at least twice the working pressure of the system, including any standing head, and a temperature range appropriate for system liquid temperature and ambient conditions.

D. The electrical housing shall be NEMA 4 rated and UL listed.

E. Switches shall be rated for at least 250 V ac inductive load and 5 amps.

F. Manufacturers - Barksdale Controls, United Electric Controls or approved equal by the Contracting Officer.

G. Current sensors may be used for fans at contractor’s option. Current sensors shall be equal to Veris Industries model Hawkeye 904. Sensors shall be for VFD application with ability to store in memory normal operations at various frequencies. Sensor must be able to detect belt loss or coupling shear.

2.15 INSTRUMENTATION CABLE

A. Cable shall be designed for transmitting a two-wire current signal over the required distance.

B. Cable shall contain two conductors (stranded type, approximately 16 X 30), 100% shielded in an aluminum polyester foil shield, and one stranded conductor drain wire. Stranded type conductors shall be No. 18 AWG wire, polyethylene insulated; drain wire shall be No. 20 AWG. All wires shall be encased in a vinyl jacket.

C. Cable shall be UL listed for 300-volt operation.

D. Manufactures - Belden, Alpha, Deloron.

E. Instrument capable may be ran in the same cable tray provided under Division 26 in the interstitial, all wiring must be in conduit in sub-basement and penthouse mechanical spaces.

F. Instrumentation cables and circuits related to smoke control systems must be installed in conduit.

2.16 WIRING AND TERMINALS

A. Electrical wiring within all equipment cabinets shall be neatly arranged in panduit, properly supported, and terminated on one side of the terminal blocks only so that all external connections for control, instrumentation, and auxiliary power can be made to the other side of the terminal blocks inside each equipment cabinet.

B. At least 20% spare unused terminal shall be provided in each group of terminal blocks. Control circuits and power circuits shall be completely separated by use of divided or separate terminal boxes. Terminal boxed for external connections shall be General Electric Type EB, designed to accommodate up to No. 12 AWG cable, and shall be provided with covers. No more than 2 wires shall be connected to any one terminal block screw. All wire connections shall be made with ring-tongue compression terminals, Burndy Type YAV.

2.17 DAMPER BLADE END SWITCHES (ELECTRIC)

A. Switches shall be momentary type limit switches for monitoring the motion of the damper at a prescribed arc of rotation.

B. Switches shall be hermetically sealed mercury switches operating against gravity by way of a 1/4 inch O.D. stainless steel rod (18 inches long and adjustable) trip lever.

C. Switches shall be either one or two SPDT contact arrangements as required with current carrying characteristics of 4 amps to 120 V ac.

D. Mechanism shall be provided with ample overtravel to avoid excessive stress on damper or control equipment.

E. Switch shall be designed to be mounted through the duct so that the trip lever will be aligned with the damper vane. Switch case shall be mounted on the exterior of the duct for electrical connections through a 13-mm conduit opening in the bottom of the case.

F. Adjustments in the case shall permit setting the position of the trip lever to actuate the mercury switch.

G. Manufacturers - Mercoid (Dwyer), Allen-Bradley Company, or approved equal by the Contracting Officer.

2.18 LIQUID DIFFERENTIAL PRESSURE TRANSMITTERS

A. The transmitter shall be capable of transmitting a linear 4 to 20 mA dc output signal proportional to the differential pressure being measured.

B. The transmitter shall be of the 2-wire design and shall meet the following requirements:

1.	Accuracy:	± 0.25% of the calibrated span.
2.	Stability:	± 0.25% of the upper range limit for 6 months.
3.	Maximum Zero Elevation:	600% of the calibrated span.
4.	Maximum Zero Suppression:	500% of the calibrated span.
5.	Zero and Span:	Continuously adjustable.
6.	Static Pressure:	2000 psi maximum.
7.	Damping:	Adjustable.
8.	Operating Temperature:	-20 degrees F to 200 degrees F.
9.	Output:	4 to 20 mA dc into minimum 450 ohms at 24 V dc.
10.	Materials of Construction:	
	a. Isolating Diaphragms:	Type 316 stainless steel.
	b. Flanges:	Cadium plated carbon steel.
11.	Range:	Suitable for the application.

C. Differential pressure transmitter shall be supplied with a 3-way manifold.

D. Manufacturers - Foxboro, Rosemount, ITT Barton.

2.19 STATIC PRESSURE INDICATING TRANSMITTERS (SPIT)

A. The duct static pressure transmitter assembly shall be composed of two major components:

1. Duct Static Pressure Transmitter with Indicator.
2. Multi-Point Averaging Static Pressure Traverse Probe. (Specified in Section 230800).

B. Duct Static Pressure Transmitter with Indicator

1. The transmitter shall transmit a linear 4 to 20 mA dc output signal proportional to the pressure being measured.
2. The transmitter shall be of 2-wire design and shall meet the following requirements:

a.	Linearity:	0.5% of span.
b.	Hysteresis:	Less than 0.005% of span.
c.	Repeatability:	Less than 0.005% of span.
d.	Temperature Effects:	0.1% of span/°C change.
e.	Maximum Static Pressure:	68.9 kPa continuous.
f.	Overload Pressure, Differential:	250% of span continuous; 400% of span short term.
g.	Signal Change Resolution:	1 part in 1000.
h.	Operating Temperature:	-32 degrees F to 120 degrees F.
i.	Span Adjustment:	± 10% of span.
j.	Zero Offset:	50% of span.
k.	Accuracy:	± 0.5% if span.
l.	Output:	4 to 20 mA dc into 0-450 ohm (minimum) load at 24 V dc supply.
m.	Full Range:	Approximately 120% of highest duct static pressure rating.

C. Multi-Point Averaging Static Pressure Traverse Probe (Specified in Section 230800).

2.20 DIFFERENTIAL PRESSURE TRANSMITTER (DPT)

A. The input of the DPT (draft range) shall match the output of the airflow measuring station (specified in Section 230800). The DPT shall be supplied with a suitable 3-way manifold connected between the station output and the transmitter input.

B. The DPT shall be capable of transmitting linear output signals proportional to velocity pressure input signals in accordance with the following requirements:

1.	Linearity:	0.05% of span.
2.	Hysteresis:	Less than 0.1% of calibrated span.
3.	Temperature Effects:	.01% of span/°C change.
4.	Static Pressure:	Maximum 68.9 kPa continuous without damage.
5.	Overload Pressure, Differential:	250% of span continuous; 400% of span short-term.
6.	Operating Temperature:	-32 degrees F to 120 degrees F
7.	Span Adjustment:	100% of span.
8.	Zero Offset:	50% of span.
9.	Accuracy:	± 0.5% of calibrated span (including linearity, hysteresis, and repeatability).
10.	Output:	4 to 20 mA dc into 0 to 450 ohm load at 24 V dc supply.
11.	Full Range:	Nominally 120% of highest duct velocity pressure to be measured to 2.5 Pa.

2.21 AHU CO2 SENSORS (AHU-1)

A. CO2 sensors shall be provided for each air -handling unit. The units shall be equal to Siemens ARG64 suitable for duct plenum mounting. The range shall be 0 to 2000ppm ±100ppm. Each unit shall be alarmable to the CCMS.

2.22 LEAK DETECTION SENSORS (AS REQUIRED)

A. Leak detection sensors for elevator sumps Typical for three locations, shall be equal to Water Bug model WB-200 with sensor type PN# 1040. Sensors shall be alarmed at the DDC system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all components and appurtenances in accordance with the manufacturer's recommendations and as shown on the Instrumentation Drawings. Provide all labor, materials, tools, appliances, equipment, devices, conduit, wiring, and additional relays if required for complete operable systems as shown on the drawings and specified herein. Installation of electrical wiring and devices shall be in accordance with Division 26.

B. Provide necessary control and interlock wiring, including solenoid valves, freezestats, fan interlocks, control panels, and other devices for a complete and operable system.

C. Provide all pneumatic control tubing and electrical wiring as shown on the Contract Drawings and as required for proper system operation.

D. Verify exact quantity and size of tubing and wiring for all systems.

E. Provide all electrical work in accordance with Division 26 of the Specifications.

F. Pipe automatic drain trap at the air compressor and refrigerated air dryer to the nearest floor drain.

G. Offset exposed control air piping around beams, girders, and other obstructions. Do not install piping through ductwork or fresh air intakes. All contact between air piping and its supports shall be prevented by permanent non-hygroscopic material. Plastic tubing bundles shall be tied at equal intervals (at least 6.1 cm on center).

H. Install air piping clear of all heat sources that have surface temperatures in excess of 51.7 degrees C.

I. Test all air piping for leaks at 276 kPa for a period of 24 hours. Pressure drop shall not exceed 5 psi.

J. If a field mounted device or piece of equipment requires 120 V ac service and is mounted at a different location from the 120 V ac power source supplied under Division 26, provide extensions to the power wiring, including conduit, junction boxes, and other hardware, all meeting the requirements of Division 26.

K. Damper operators shall not be installed in ducts or fresh air intakes.

L. Thermostats and humidistats located on exterior walls shall be mounted on black insulated blocks.

M. Install room thermostats, temperature sensors, and humidistats 48 inches above the finished floor or as directed by the Architect. All exhaust sensors shall be sealed after insertion into ductwork, sensors shall be located at the nearest common duct header that has effectively collected all the room exhaust.

N. Provide wiring of freezestats into the BAS.

O. If there is any question as to the validity of any control, alarm, and/or interlock wiring, verify to the Contracting Officer that field wiring has been done in accordance with Division 26 and has been properly connected to the appropriate device(s) as shown on the Contract Drawings.

P. Provide air pressure gauges on all pneumatic tubing to and from all thermostats, valves, air operators, pneumatic transmitters, and all other pneumatically operated devices so that the operation of each component of pneumatically controlled equipment can be checked at the location of the device.

Q. Provide, at each duct thermostat and temperature sensor and where else shown on the drawings, direct reading duct thermometers that are readable by a person standing on the floor so that thermostat/sensor operation can be checked.

R. Provide a pressure gauge at each reheat coil hot water control valve as shown. If the valve is located above the ceiling, the gauge shall be readable through an access door.

S. Install field equipment panels so that they are stable and fully supported. Locate panels a minimum of 25 mm from the wall.

T. Operators for constant volume and VAV boxes will be provided under Division 23900.

U. Power wiring to control panels, and equipment such as air dryers, will be provided in accordance with Division 26.

V. Provide approximately twenty (20) man days labor for coordination during testing and balancing of systems as performed under Section 230593. The time shall be directed in writing by the Contracting Officer.

W. Provide complete data on requirements of equipment and system to other trades when required.

X. If the DDC Contractor places the Field Equipment Panels (FEPs) at locations different from those shown on the drawings, the DDC System Contractor shall extend all related accessories, including housekeeping pads and power wiring, and all other tubing and wiring, to the new locations and make all necessary connections required at the new locations. Also, provide all additional electrical wiring and related equipment other than that provided in accordance with Division 26 and in accordance with the DDC manufacturer's recommended instructions.

Y. If more field equipment than those shown on the drawings are required, all requirements of these specification shall apply to these panels.

Z. FEPs are shown on HVAC plans for approximate location and space allocation only, and are not shown dimensionally or quantitatively. The total number of FEPs required shall be determined by actual FEP point capacities and spare point requirements of the Contract Documents. Requirements of these specifications shall apply to each FEP on the project. It shall be the responsibility of this Contractor to provide all related accessories, including the extension of housekeeping pads, and power wiring to all additional FEP panels necessary to complete this contract.

AA. Provide all necessary cooperation and coordination with the Division 26 Contractor such that all power and ground wiring is provided in strict accordance with the DDC equipment manufacturer's recommendations. The DDC system supplier/installer shall make all final electrical connections to the DDC system equipment.

BB. For NEMA 12 cabinets, provide electrical isolation between cooling fan and thermostat and the electronics in the cabinet such that the cooling fan operation does not affect operation.

CC. At all penetrations through designated vapor retardant walls (See Architectural Drawings), provide patching and sealant with FDA approved silicone caulk. Also provide air and vapor tight sealing of shielded air probes (SAPs) with FDA approved silicone caulk.

1. Temperature:

   a. RTDs - RTDs may be used in ducts, piping, or spaces. When the RTD is installed in pipes, it shall be installed in a thermowell. When installed in airstreams or spaces, the RTDs shall be rigidly supported. RTDs used for space temperature sensing shall include a housing suitable for wall mounting. RTDs used for outside air sensing shall have an instrument shelter to minimize solar effects, assemblies shall be readily accessible and installed in such a manner as to allow for easy replacement. Sensors located outdoors shall be NEMA 4 rated.

   b. Temperature Switches - Install temperature switches as specified for RTDs. Temperature switches shall be verified by calibration. Switch contact ratings shall be selected so as to meet the expected load.

   c. Average Temperature Elements - Mount average temperature elements inside the ducts in such a manner to provide the most representative temperature profile.

2. Humidity:

   a. Relative Humidity - Provide air guards/sintered filters when there are air flows greater than 50 fpm across the sensor element. Sensors located outdoors shall be NEMA 4 rated.

3. Pressure:

   a. Pressure Sensors - Pressure sensors (all types) installed on steam and liquid lines shall have siphons. All pressure sensors shall have valves for isolation and venting, and taps for calibration. Pressure sensors shall be verified by calibration. Differential pressure sensors shall have three-way manifold valves.

   b. Pressure Switches - Pressure switches (all types) installed on steam and liquid lines shall have siphons. All pressure switches shall have valves for isolation and venting, and taps for calibration. Pressure switches shall be adjusted to the proper set point, and shall be verified by calibration. Pressure switches shall be mounted higher than the process connection. Differential pressure switches shall have three-way manifold valves. Switch contact ratings and duty shall be selected for the expected load.

   c. Provide all necessary pressure fittings (in addition to that shown on Division 23 Contract Drawings) for installation.

   d. Size (for the specific range) and adjust each differential pressure switch used for fan and pump status to ensure reliable monitoring and eliminate false status feedback.

e. Keep cable runs as short as possible, allowing extra length for connecting to terminal boards. Use sleeves or grommets to protect cables from vibration at points where they pass around sharp corners or through penetrations.

3.2 COMMISSIONING

A. Refer to Sections 230800.

3.3 GUARANTEE AND SERVICE

A. Instrumentation and control equipment shall be guaranteed in writing against defects in workmanship and defective materials for a period of one (1) year after acceptance by the Government. During this time, instrumentation and control equipment shall be kept in proper operating condition at no additional cost to the Government.

B. Instrumentation and control equipment shall be accepted only after they have been fully installed and their performance verified by the Contracting Officer.

C. Provide one (1) year free service on all instrumentation and control equipment and components during the guarantee period.

END OF SECTION 230910

SECTION 232113 - 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. Section includes pipe and fitting materials and joining methods for the following:
   1. Hot-water heating piping.
   2. Chilled-water piping.
   3. Condensate-drain piping.
   4. Steam piping.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of the following:
   1. Plastic pipe and fittings with solvent cement.
   2. RTRP and RTRF with adhesive.
   3. Pressure-seal fittings.
   4. Chemical treatment.

B. Delegated-Design Submittal:
   1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
   2. Locations of pipe anchors and alignment guides and expansion joints and loops.
   3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
   4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
   1. Suspended ceiling components.
   2. Other building services.
   3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Installer Qualifications:
1. Installers of Pressure-Sealed Joints: Installers shall be certified by pressure-seal joint manufacturer as having been trained and qualified to join piping with pressure-seal pipe couplings and fittings.

B. Steel Support Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature unless otherwise indicated:
1. Hot-Water Heating Piping: at 200 deg F.
2. Chilled-Water Piping: at 200 deg F.
3. Air-Vent Piping: 200 deg F.

2.2 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.

C. DWV Copper Tubing: ASTM B 306, Type DWV.

D. Grooved, Mechanical-Joint, Wrought-Copper Fittings: ASME B16.22.
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Anvil International, Inc.
b. Star Pipe Products.
2. Grooved-End Copper Fittings: ASTM B 75, copper tube or ASTM B 584, bronze casting.
3. Grooved-End-Tube Couplings: Rigid pattern unless otherwise indicated; gasketed fitting. Ductile-iron housing with keys matching pipe and fitting grooves, EPDM gasket rated for minimum 230 deg F for use with housing, and steel bolts and nuts.

E. Copper or Bronze Pressure-Seal Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following :

a. NIBCO INC.
b. Viega.
2. Housing: Copper.
3. O-Rings and Pipe Stops: EPDM.
4. Tools: Manufacturer's special tools.
5. Minimum 200-psig working-pressure rating at 250 deg F.

F. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
1. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
a. T-DRILL Industries Inc.

G. Wrought-Copper Unions: ASME B16.22.

2.3 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in "Piping Applications" Article.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in "Piping Applications" Article.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in "Piping Applications" Article.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in "Piping Applications" Article.

F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.

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

H. Grooved Mechanical-Joint Fittings and Couplings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Anvil International, Inc.
b. Central Sprinkler Company.
c. Star Pipe Products.
2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron; ASTM A 47/A 47M, Grade 32510 malleable iron; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106/A 106M, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
3. Couplings: Ductile- or malleable-iron housing and EPDM gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

2.4 STEAM PIPING

A. Carbon steel pipe, ASTM A106 Grade B, Type S seamless, Schedule 40

B. Fitting shall be cast iron threaded fittings, ANSI B16.4. Fittings shall be 125 lb. minimum for less than 75 PSI and 250 lb. minimum for pressures above 75 PSI. Steam condensate shall be 250 lb. minimum for all pressures.

C. Threaded fitting shall use American Standard for Pipe Threads, ANSI B2.1 with thread sealant or Teflon tape material especially listed compatible with system contents, pipe materials, and operating conditions.

2.5 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 otherwise 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.

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

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

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

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

F. Solvent Cements for Joining Plastic Piping:
1. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
   a. PVC solvent cement shall have a VOC content of 510 g/L or less.
   b. Adhesive primer shall have a VOC content of 550 g/L or less.

2.6 TRANSITION FITTINGS

A. Plastic-to-Metal Transition Fittings:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Charlotte Pipe and Foundry Company.
   b. IPEX Inc.
   c. KBI (King Bros. Industries).
2. One-piece fitting with one threaded brass or copper insert and one solvent-cement-joint end of material and wall thickness to match plastic pipe material.

B. Plastic-to-Metal Transition Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Charlotte Pipe and Foundry Company.

b. IPEX Inc.
c. KBI (King Bros. Industries).
d. NIBCO INC; Model #T/S-1710.

2. Brass or copper end, solvent-cement-joint end of material and wall thickness to match plastic pipe material, rubber gasket, and threaded union.

2.7 DIELECTRIC FITTINGS

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

B. Dielectric Unions:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. A.Y. McDonald Mfg. Co.
b. Capitol Manufacturing Company.
c. Central Plastics Company.
d. Hart Industries International, Inc.
e. Jomar International, Ltd.
f. Matco-Norca.
g. Watts Regulator Co.
h. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.
2. Description:
a. Standard: ASSE 1079.
b. Pressure Rating: 125 psig minimum at 180 deg F.
c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Capitol Manufacturing Company.
b. Central Plastics Company.
c. Matco-Norca.
d. Watts Regulator Co.
e. Zurn Industries, LLC; AquaSpec Commercial Faucet Products.
2. Description:
a. Standard: ASSE 1079.
b. Factory-fabricated, bolted, companion-flange assembly.
c. Pressure Rating: 125 psig minimum at 180 deg F.
d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
a. Advance Products & Systems, Inc.
b. Calpico, Inc.
c. Central Plastics Company.
d. Pipeline Seal and Insulator, Inc.
2. Description:
a. Nonconducting materials for field assembly of companion flanges.
b. Pressure Rating: 150 psig.
c. Gasket: Neoprene or phenolic.
d. Bolt Sleeves: Phenolic or polyethylene.
e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
   a. Elster Perfection.
   b. Grinnell Mechanical Products.
   c. Matco-Norca.
   d. Precision Plumbing Products, Inc.
   e. Victaulic Company.
2. Description:
   a. Standard: IAPMO PS 66.
   b. Electroplated steel nipple, complying with ASTM F 1545.
   c. Pressure Rating: 300 psig at 225 deg F.
   d. End Connections: Male threaded or grooved.
   e. Lining: Inert and noncorrosive, propylene.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Hot-water heating piping, aboveground, NPS 2-1/2 and smaller, shall be any of the following:
1. Type L Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40, Grade B, Type 96 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Hot-water heating piping, aboveground, NPS 3 and larger, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; All welds shall be electric welded.

C. Chilled-water piping, aboveground, NPS 2-1/2 and smaller, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

D. Chilled-water piping, aboveground, NPS 3 and larger, shall be any of the following:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. Schedule 40 steel pipe; welds shall be electric welded.

E. Condensate-Drain Piping: Type M, drawn-temper copper tubing, wrought-copper fittings, and soldered joints or Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

F. Air-Vent Piping:
1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using mechanically formed tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."

Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

S. Install shutoff valve immediately upstream of each dielectric fitting.

T. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

U. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

V. Install sleeves for piping penetrations of walls, ceilings, and floors. Comply with requirements for sleeves specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

W. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."

X. Install escutcheons for piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons specified in Section 230518 "Escutcheons for HVAC Piping."

3.3 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric unions.

C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges.

D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.4 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. 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.
6. On plastic pipe, install pads or cushions on bearing surfaces to prevent hanger from scratching pipe.

D. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 7 feet.
2. NPS 1: Maximum span, 7 feet.
3. NPS 1-1/2: Maximum span, 9 feet.
4. NPS 2: Maximum span, 10 feet.
5. NPS 2-1/2: Maximum span, 11 feet.
6. NPS 3 and Larger: Maximum span, 12 feet.

E. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
3. NPS 1-1/4Maximum span, 7 feet; minimum rod size, 3/8 inch.
4. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
5. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.

6. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
7. NPS 3 and Larger: Maximum span, 10 feet; minimum rod size, 3/8 inch.

F. Plastic Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

G. Fiberglass Piping Hanger Spacing: Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.

H. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

I. All hangers and supports shall be corrosive resistant, ie. 304 stainless steel, in all seawater environments/rooms.

3.5 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. 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.

D. 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/A5.8M.

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.

F. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

G. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

H. Plastic Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
2.
3. PVC Pressure Piping: Join ASTM D 1785 schedule number, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule number PVC pipe and socket fittings according to ASTM D 2855.
4. PVC Nonpressure Piping: Join according to ASTM D 2855.

I. 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.

J. Mechanically Formed, Copper-Tube-Outlet Joints: Use manufacturer-recommended tool and procedure, and brazed joints.

K. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.6 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. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.7 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:
1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 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 the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.

6. Prepare written report of testing.

C. Perform the following before operating the system:
1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 233113 - METAL DUCTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:
1. Single-wall rectangular ducts and fittings.
2. Double-wall rectangular ducts and fittings.
3. Single-wall round ducts and fittings.
4. Double-wall round and flat-oval ducts and fittings.
5. Sheet metal materials.
6. Sealants and gaskets.
7. Hangers and supports.
8. Seismic-restraint devices.

B. Related Sections:
1. Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing requirements for metal ducts.
2. Section 233300 "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.3 PERFORMANCE REQUIREMENTS

A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

B. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7. SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems.".
1. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of the following products:
1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

B. Shop Drawings:
1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
2. Factory- and shop-fabricated ducts and fittings.
3. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
4. Elevation of top of ducts.
5. Dimensions of main duct runs from building grid lines.
6. Fittings.
7. Reinforcement and spacing.
8. Seam and joint construction.
9. Penetrations through fire-rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.

C. Delegated-Design Submittal:
1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.
5. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.

1.5 INFORMATIONAL SUBMITTALS

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

B. Welding certificates.

C. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports. AWS D1.2/D1.2M, "Structural

Welding Code - Aluminum," for aluminum supports. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Welding Qualifications: Qualify procedures and personnel according to the following:
   1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
   2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
   3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

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

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

PART 2 - PRODUCTS

2.1 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.2 SINGLE-WALL ROUND DUCTS AND FITTINGS

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
   1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
      a. Lindab Inc.
      b. McGill AirFlow LLC.
      c. SEMCO Incorporated.
      d. Sheet Metal Connectors, Inc.
      e. Spiral Manufacturing Co., Inc.

B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Transverse Joints in Ducts Larger Than 60 Inches in Diameter: Flanged.

C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
   1. Fabricate round ducts larger than 90 inches in diameter with butt-welded longitudinal seams.
   2. Fabricate flat-oval ducts larger than 72 inches in width (major dimension) with butt-welded longitudinal seams.

D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.3 SHEET METAL MATERIALS

A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
   1. Galvanized Coating Designation: G90.
   2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum 1 mil thick on opposite surface.
   3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.

D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.

E. Factory- or Shop-Applied Antimicrobial Coating:
   1. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
   2. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
   3. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
   4. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

5. Shop-Applied Coating Color: White.
6. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.

F. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.4 SEALANT AND GASKETS

A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.

B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
2. Tape Width: 3 inches.
3. Sealant: Modified styrene acrylic.
4. Water resistant.
5. Mold and mildew resistant.
6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
7. Service: Indoor and outdoor.
8. Service Temperature: Minus 40 to plus 200 deg F.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
11. Sealant 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."

C. 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.

D. Solvent-Based Joint and Seam Sealant:
1. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. VOC: Maximum 395 g/L.

E. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.
6. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
7. Sealant 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."

F. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

G. Round Duct Joint O-Ring Seals:
1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.5 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

F. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

G. Any new ducts located in the ceiling of an existing seawater labs or exposed seawater areas, all duct hangers, hanging rods and supports shall be 304 stainless steel to prevent from corrosion.

H. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
2. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

2.6 SEISMIC-RESTRAINT DEVICES

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.; a division of Cooper Industries.
2. Ductmate Industries, Inc.
3. Hilti Corp.

4. Kinetics Noise Control.
5. Loos & Co.; Cableware Division.
6. Mason Industries.
7. TOLCO; a brand of NIBCO INC.
8. Unistrut Corporation; Tyco International, Ltd.

B. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
   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.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A 603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.

B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

C. Install round and flat-oval ducts in maximum practical lengths.

D. Install ducts with fewest possible joints.

E. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.

F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

H. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.

I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.

J. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.

K. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Section 233300 "Air Duct Accessories" for fire and smoke dampers.

L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

3.2 INSTALLATION OF EXPOSED DUCTWORK

A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.

D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 DUCT SEALING

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

B. Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
2. Outdoor, Supply-Air Ducts: Seal Class A.
3. Outdoor, Exhaust Ducts: Seal Class C.
4. Outdoor, Return-Air Ducts: Seal Class C.
5. Unconditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class B.
6. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class A.
7. Unconditioned Space, Exhaust Ducts: Seal Class C.
8. Unconditioned Space, Return-Air Ducts: Seal Class B.

9. Conditioned Space, Supply-Air Ducts in Pressure Classes 2-Inch wg and Lower: Seal Class C.
10. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than 2-Inch wg: Seal Class B.
11. Conditioned Space, Exhaust Ducts: Seal Class B.
12. Conditioned Space, Return-Air Ducts: Seal Class C.

3.4 HANGER AND SUPPORT INSTALLATION

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

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
5. Do not use powder-actuated concrete fasteners for seismic restraints.

C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.

D. Hangers Exposed to View: Threaded rod and angle or channel supports.

E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet.

F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.5 SEISMIC-RESTRAINT-DEVICE INSTALLATION

A. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems."
1. Space lateral supports a maximum of 40 feet o.c., and longitudinal supports a maximum of 80 feet o.c.
2. Brace a change of direction longer than 12 feet.

B. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.

C. Install cables so they do not bend across edges of adjacent equipment or building structure.

D. Install cable restraints on ducts that are suspended with vibration isolators.

E. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction.

F. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

G. Drilling for and Setting Anchors:
1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Architect 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. Set anchors to manufacturer's recommended torque, using a torque wrench.
5. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.

3.6 CONNECTIONS

A. Make connections to equipment with flexible connectors complying with Section 233300 "Air Duct Accessories."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.7 PAINTING

A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Section 099113 "Exterior Painting" and Section 099123 "Interior Painting."

3.8 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Leakage Tests:
1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Test the following systems:
   a. Ducts with a Pressure Class Higher Than 3-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
   b. Supply Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.

c. Exhaust Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.
d. Outdoor Air Ducts with a Pressure Class of 2-Inch wg or Higher: Test representative duct sections totaling no less than 50 percent of total installed duct area for each designated pressure class.

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

C. Duct System Cleanliness Tests:
1. Visually inspect duct system to ensure that no visible contaminants are present.
2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.

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

E. Prepare test and inspection reports.

3.9 DUCT CLEANING

A. Clean new and existing duct system(s) before testing, adjusting, and balancing.

B. Use service openings for entry and inspection.
1. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Section 233300 "Air Duct Accessories" for access panels and doors.
2. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
3. Remove and reinstall ceiling to gain access during the cleaning process.

C. Particulate Collection and Odor Control:
1. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
2. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.

D. Clean the following components by removing surface contaminants and deposits:
1. Air outlets and inlets (registers, grilles, and diffusers).
2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
3. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.

4. Coils and related components.
5. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
6. Supply-air ducts, dampers, actuators, and turning vanes.
7. Dedicated exhaust and ventilation components and makeup air systems.

E. Mechanical Cleaning Methodology:
1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
4. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
5. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
6. Provide drainage and cleanup for wash-down procedures.
7. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.

3.10 START UP

A. Air Balance: Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC."

3.11 DUCT SCHEDULE

A. Supply and Return Ducts:
1. Ducts Connected to Variable-Air-Volume Air-Handling Units:
   a. Pressure Class: Positive 4-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive 3-inch wg .
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

B. Exhaust Ducts:
1. Ducts Connected to Air-Handling Units:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.
2. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
   a. Pressure Class: Negative 2-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 6.

d. SMACNA Leakage Class for Round and Flat Oval: 6.

3. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A Welded seams, joints, and penetrations.
   c. SMACNA Leakage Class: 3.
4. Ducts Connected to Equipment Not Listed Above:
   a. Pressure Class: Positive or negative 3-inch wg.
   b. Minimum SMACNA Seal Class: A if negative pressure, and A if positive pressure.
   c. SMACNA Leakage Class for Rectangular: 6.
   d. SMACNA Leakage Class for Round and Flat Oval: 6.

C. Intermediate Reinforcement:
1. Galvanized-Steel Ducts: Galvanized steel.
2. Aluminum Ducts: Aluminum.

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

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

END OF SECTION 233113

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. Section Includes:
1. Manual volume dampers.
2. Control dampers.
3. Flange connectors.
4. Turning vanes.
5. Duct-mounted access doors.
6. Flexible connectors.
7. Flexible ducts.
8. Duct accessory hardware.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

B. LEED Submittals:
1. Product Data for Prerequisite IEQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
2. Product Data for Prerequisite EA 2: Documentation indicating that duct insulation R-values comply with tables in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air Conditioning."

C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
a. Special fittings.
b. Manual volume damper installations.
c. Control-damper installations.
d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
e. Duct security bars.
f. Wiring Diagrams: For power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

B. Source quality-control reports.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.6 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. Fusible Links: Furnish quantity equal to 10 percent of amount installed.

PART 2 - PRODUCTS

2.1 ASSEMBLY DESCRIPTION

A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

2.2 MATERIALS

A. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
1. Galvanized Coating Designation: G90.
2. Exposed-Surface Finish: Mill phosphatized.

B. Aluminum Sheets: Comply with ASTM B 209, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.

C. Extruded Aluminum: Comply with ASTM B 221, Alloy 6063, Temper T6.

D. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.

E. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.3 MANUAL VOLUME DAMPERS

A. Standard, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. Flexmaster U.S.A., Inc.
   d. McGill AirFlow LLC.
   e. Nailor Industries Inc.
   f. Pottorff.
   g. Ruskin Company.
   h. Trox USA Inc.
   i. Vent Products Company, Inc.
3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames:
   a. Frame: Hat-shaped, 0.094-inch- thick, galvanized sheet steel.
   b. Mitered and welded corners.
   c. Flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized-steel, 0.064 inch thick.
7. Blade Axles: Galvanized steel.
8. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Galvanized steel.

B. Standard, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.
3. Standard leakage rating, with linkage outside airstream.
4. Suitable for horizontal or vertical applications.
5. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
6. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.

e. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
7. Blade Axles: Galvanized steel.
8. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
9. Tie Bars and Brackets: Aluminum.

C. Low-Leakage, Steel, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.
   e. Pottorff.
   f. Ruskin Company.
   g. Trox USA Inc.
   h. Vent Products Company, Inc.
3. Comply with AMCA 500-D testing for damper rating.
4. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
5. Suitable for horizontal or vertical applications.
6. Frames:
   a. Hat shaped.
   b. 0.094-inch- thick, galvanized sheet steel.
   c. Mitered and welded corners.
   d. Flanges for attaching to walls and flangeless frames for installing in ducts.
7. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Stiffen damper blades for stability.
   d. Galvanized, roll-formed steel, 0.064 inch thick.
8. Blade Axles: Galvanized steel.
9. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
10. Blade Seals: Neoprene.
11. Jamb Seals: Cambered stainless steel.
12. Tie Bars and Brackets: Aluminum.
13. Accessories:
   a. Include locking device to hold single-blade dampers in a fixed position without vibration.

D. Low-Leakage, Aluminum, Manual Volume Dampers:
1. Manufacturers: Subject to compliance with requirements, provide products by the following:
2. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
   a. Air Balance Inc.; a division of Mestek, Inc.
   b. American Warming and Ventilating; a division of Mestek, Inc.
   c. McGill AirFlow LLC.
   d. Nailor Industries Inc.

e. Pottorff.
f. Ruskin Company.
g. Trox USA Inc.
h. Vent Products Company, Inc.

3. Comply with AMCA 500-D testing for damper rating.
4. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
5. Suitable for horizontal or vertical applications.
6. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
7. Blades:
   a. Multiple or single blade.
   b. Parallel- or opposed-blade design.
   c. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
   d. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
8. Blade Axles: Galvanized steel.
9. Bearings:
   a. Oil-impregnated bronze.
   b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
10. Blade Seals: Neoprene.
11. Jamb Seals: Cambered stainless steel.
12. Tie Bars and Brackets: Aluminum.
13. Accessories:
    a. Include locking device to hold single-blade dampers in a fixed position without vibration.

E. Jackshaft:
1. Size: 0.5-inch diameter.
2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

F. Damper Hardware:
1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.4 CONTROL DAMPERS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. American Warming and Ventilating; a division of Mestek, Inc.
2. Arrow United Industries; a division of Mestek, Inc.
3. Cesco Products; a division of Mestek, Inc.
4. Greenheck Fan Corporation.
5. Lloyd Industries, Inc.
6. McGill AirFlow LLC.
7. Metal Form Manufacturing, Inc.
8. Nailor Industries Inc.
9. NCA Manufacturing, Inc.

10. Pottorff.
11. Ruskin Company.
12. Vent Products Company, Inc.
13. Young Regulator Company.

C. Low-leakage rating, with linkage outside airstream, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.

D. Frames:
1. Hat shaped.
2. 0.094-inch- thick, galvanized sheet steel.
3. Interlocking, gusseted corners.

E. Blades:
1. Multiple blade with maximum blade width of 6 inches.
2. Parallel- and opposed-blade design.
3. Galvanized-steel.
4. 0.064 inch thick single skin.
5. Blade Edging: Closed-cell neoprene.

F. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
1. Operating Temperature Range: From minus 40 to plus 200 deg F.

G. Bearings:
1. Oil-impregnated bronze.
2. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
3. Thrust bearings at each end of every blade.

2.5 FLANGE CONNECTORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Ductmate Industries, Inc.
2. Nexus PDQ; Division of Shilco Holdings Inc.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.

D. Material: Galvanized steel.

E. Gage and Shape: Match connecting ductwork.

2.6 TURNING VANES

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. METALAIRE, Inc.
5. SEMCO Incorporated.
6. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

D. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.

E. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."

F. Vane Construction: Single wall.

2.7 DUCT-MOUNTED ACCESS DOORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. American Warming and Ventilating; a division of Mestek, Inc.
2. Cesco Products; a division of Mestek, Inc.
3. Ductmate Industries, Inc.
4. Elgen Manufacturing.
5. Flexmaster U.S.A., Inc.
6. Greenheck Fan Corporation.
7. McGill AirFlow LLC.
8. Nailor Industries Inc.
9. Pottorff.
10. Ventfabrics, Inc.
11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
1. Door:
   a. Double wall, rectangular.
   b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
   c. Vision panel.
   d. Hinges and Latches: 1-by-1-inchbutt or piano hinge and cam latches.
   e. Fabricate doors airtight and suitable for duct pressure class.
2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
3. Number of Hinges and Locks:
   a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
   b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.

c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

D. Pressure Relief Access Door:
1. Door and Frame Material: Galvanized sheet steel.
2. Door: Double wall with insulation fill with metal thickness applicable for duct pressure class.
3. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
4. Factory set at 3.0- to 8.0-inch wg.
5. Doors close when pressures are within set-point range.
6. Hinge: Continuous piano.
7. Latches: Cam.
8. Seal: Neoprene or foam rubber.
9. Insulation Fill: 1-inch- thick, fibrous-glass or polystyrene-foam board.

2.8 DUCT ACCESS PANEL ASSEMBLIES

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Ductmate Industries, Inc.
2. Flame Gard, Inc.
3. 3M.

C. Labeled according to UL 1978 by an NRTL.

D. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.

E. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.

F. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.

G. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.9 FLEXIBLE CONNECTORS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Ductmate Industries, Inc.
2. Duro Dyne Inc.
3. Elgen Manufacturing.
4. Ventfabrics, Inc.
5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Materials: Flame-retardant or noncombustible fabrics.

D. Coatings and Adhesives: Comply with UL 181, Class 1.

E. Metal-Edged Connectors: Factory fabricated with a fabric strip 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized sheet steel or 0.032-inch- thick aluminum sheets. Provide metal compatible with connected ducts.

F. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
1. Minimum Weight: 26 oz./sq. yd..
2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
3. Service Temperature: Minus 40 to plus 200 deg F.

G. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
1. Minimum Weight: 24 oz./sq. yd..
2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
3. Service Temperature: Minus 50 to plus 250 deg F.

H. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
1. Minimum Weight: 16 oz./sq. yd..
2. Tensile Strength: 285 lbf/inch in the warp and 185 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

I. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
1. Minimum Weight: 14 oz./sq. yd..
2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
3. Service Temperature: Minus 67 to plus 500 deg F.

J. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
2. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.10 FLEXIBLE DUCTS

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

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Flexmaster U.S.A., Inc.
2. McGill AirFlow LLC.
3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.

C. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
   1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
   2. Maximum Air Velocity: 4000 fpm.
   3. Temperature Range: Minus 10 to plus 160 deg F.
   4. Insulation R-value: Comply with ASHRAE/IESNA 90.1.

D. Flexible Duct Connectors:
   1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.
   2. Non-Clamp Connectors: Adhesive plus sheet metal screws.

2.11 DUCT ACCESSORY HARDWARE

A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.

B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.

B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

C. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
   1. Install steel volume dampers in steel ducts.
   2. Install aluminum volume dampers in aluminum ducts.

D. Set dampers to fully open position before testing, adjusting, and balancing.

E. Install test holes at fan inlets and outlets and elsewhere as indicated.

F. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
   1. On both sides of duct coils.
   2. Upstream and downstream from duct filters.
   3. At outdoor-air intakes and mixed-air plenums.
   4. At drain pans and seals.
   5. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.

6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
7. At each change in direction and at maximum 50-foot spacing.
8. Upstream and downstream from turning vanes.
9. Upstream or downstream from duct silencers.
10. Control devices requiring inspection.
11. Elsewhere as indicated.

G. Install access doors with swing against duct static pressure.

H. Access Door Sizes:
1. One-Hand or Inspection Access: 8 by 5 inches.
2. Two-Hand Access: 12 by 6 inches.
3. Head and Hand Access: 18 by 10 inches.
4. Head and Shoulders Access: 21 by 14 inches.
5. Body Access: 25 by 14 inches.
6. Body plus Ladder Access: 25 by 17 inches.

I. Label access doors according to Section 230553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.

J. Install flexible connectors to connect ducts to equipment.

K. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.

L. Connect terminal units to supply ducts directly or with maximum 12-inch lengths of flexible duct. Do not use flexible ducts to change directions.

M. Connect diffusers or light troffer boots to ducts directly or with maximum 60-inch lengths of flexible duct clamped or strapped in place.

N. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.

O. Install duct test holes where required for testing and balancing purposes.

P. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

3.2 FIELD QUALITY CONTROL

A. Tests and Inspections:
1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 233300

SECTION 237330 – CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.1 WORK INCLUDED

A. The work under this Section shall include furnishing all materials, equipment and performing all operations necessary for the complete production, packaging, delivery, factory testing and assembling the custom units.

B. This Section covers only the units indicated as "CUSTOM" on the Air Handling Unit Schedule.

C. The units shall consist of base, enclosures, access doors, insulation, wiring systems, electrical components, and all components specified to be installed by the air handling unit manufacturer within the enclosures.

D. The unit(s) shall be factory fabricated to completion as an assembled unit and then separated into individual shipping sections only after the unit(s) are complete, tested and have been inspected by the Owner's representatives.

E. Sections shall be joined by bolting through gasketed field flanges which are pre-drilled with matching holes at both the base rail and continuously around the full perimeter (floor, walls, and roof) of the unit housing. Bolting shall be accomplished from the unit interior to provide a clean exterior appearance.

F. The unit manufacturer shall include in his design, the structural framing and pipe supports for the piping systems within the unit(s).

G. The unit base and structure shall be designed such that each section of the unit is self-supporting. The unit(s) shall be designed to operate properly when installed on the support structure provided as indicated. The installation of any additional support members beyond those indicated will be at the expense of the unit manufacturer.

H. The unit manufacturer shall ship the unit with blank-off plates suitably sealed to allow for field air leakage testing to occur.

I. Units with energy recovery coils shall be coordinated between the existing pumps, piping and existing to remain coils in located exhaust plenum.

1.2 REFERENCES

A. Design and fabrication shall be in accordance with the latest editions of the energy recovery media owing codes, ordinances and standards, where applicable.

AMCA 203	Field performance measurements.
AMCA 300	Laboratory methods of testing fans for rating purposes. Test Code for Sound rating air moving devices.
ASHRAE 68-78	In-duct sound power measurements procedure for fans.

ANSI/AFBMA 9	Load ratings and fatigue life for ball bearings.
ARI	Air Conditioning and Refrigeration Institute.
SMACNA	HV AC Metal Duct Standards.
ASTM A386	Zinc coating (hot-dip) on assembled steel products.
ASTM A525	Steel sheet, zinc coated (galvanized) by hot-dip process.
ASTM B209	Aluminum - alloy sheet and plate.
ASTM B221	Aluminum alloy extruded bars, rod, wire, shapes, and tubes.
ASTM B251	General requirements for wrought seamless copper and copper-alloy tube.
ASTM E84	Test for surface burning characteristics of building materials.
OSHA	Occupational Safety and Health Administration.
ARI 410	Forced-circulation air cooling and air heating coils.
ASHRAE 33-78	Methods of testing forced circulation air cooling and heating coils.
NEC	National Electric Code.
NEMA	National Electrical Manufacturers Association.
UL	Underwriters Laboratory.

DRAWING REFERENCES

Air handling unit detail drawings.

Equipment schedules.

1.3 QUALITY ASSURANCE

A. Fabrication: Conform to AMCA 99.

B. Air handling units: Product of manufacturer regularly engaged in production of custom built air handling units.

C. Ductwork and equipment installation shall be in accordance with the current editions of NFPA Air Conditioning and Ventilating System Code 90-A and B.

D. Sound power level ratings: Comply with AMCA Standard 301 "Method of Calculating Fan Sound Power Ratings from Laboratory Test Data." Test fans in accordance with AMCA Standard 300 "Test Code for Sound Rating" Fans shall be licensed to bear the AMCA Seal for Air and Sound.

E. UL Compliance: Electrical components shall be UL listed and labeled.

F. NFPA Compliance: Provide air handling unit insulating materials having flame spread ratings not over 25 and smoke developed ratings no higher than 50; and complying with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" Manufacturer shall provide a copy of NFPA 90 test certificate as part of the submittal to indicate compliance.

G. NEMA Compliance: Motors and electrical accessories shall comply with NEMA Stan-dards.

H. Electrical Component Standard: Components and installation shall comply with NFPA 70"National Electric Code".

I. The air handling unit(s) shall be run tested as specified herein at the manufacturer's facility. A certified run test report shall be furnished prior to shipment.

J. Panel acoustical performance shall be as tested by an independent acoustical laboratory (Riverbank Labs or equivalent) in accordance with ASTM requirements. Submit certified test data for the panels to be utilized.

K. Performance data of filters shall be based on ASHRAE 52.1 and ASHRAE 52.2.

L. Coil performance data shall be certified in accordance with ARI Standard 410.

M. Qualify welding procedures and welding operators in accordance with American Welding Society (AWS) - Structural Welding Code.

N. Units must be constructed or coated for a sea water atmosphere.

O. Units for this project shall be Grade “A” units.

1.4 SUBMITTALS

A. Submit shop drawings and product data in accordance with Division 1 Section Submittal Procedures.

B. All equipment components to be provided in a factory type custom unit shall be submitted together as a single package. Equipment descriptive literature and component performance data shall be submitted. Provide fan curves for all fans.

C. Shop drawings of custom type units shall include cross-sections and details of casing construction, dimensions, weights, clearances, locations and size of field connections and details of construction shall be submitted for approval. Shop drawings shall be provided in a scale no less than 1/4” + 1'-0". Obtain approval prior to beginning fabrication.

D. Detailed manufacturer's descriptive literature, configuration, materials of construction, performance curves, dimensions, capacities, installation and operating instructions, parts lists,

etc. required to demonstrate compliance with specifications shall be submitted for review of bid and for approval prior to fabrication.

E. Submit detailed shop drawings showing all control dampers, access doors, air terminals, splitters, turning vanes, and accessories including class, material, duct gauge, duct sizes, welds, and configurations.

F. Submit eight octave band sound power level ratings for all fans.

G. Provide wiring diagrams and terminal points for control panels provided with units.

H. Manufacturer shall provide a copy of NFPA 90 test certificate as part of the submittal to indicate compliance.

I. Manufacturer shall provide certified acoustical test data for the panels to be utilized.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver the unit(s) as a factory assembled unit to the extent allowable by shipping limitations.

B. Shipping sections with exposed openings shall be properly covered by the unit manufacturer, prior to shipment, to protect the unit and components during transportation.

C. Handle carefully to avoid damage to components, enclosures, and finish. Do not install damaged components; remove and replace damaged components as required or directed.

D. Deliver the unit with factory installed shipping skids and lifting lugs; pack components in factory-fabricated protective containers, suitably marked to indicate the contents within.

E. All components shall be properly braced as necessary to prevent damage during transportation and rigging.

F. During temporary storage, the installing contractor shall provide suitable protection and perform the necessary preventative maintenance to provide the unit in "like new" condition.

G. Furnish written instructions needed to complete the field assembly of the unit. Provide all sealing and fastening hardware required.

1.6 SEQUENCING AND SCHEDULING

A. Coordinate the sizes and locations of housekeeping pads field installed by the Contractor.

B. Coordinate services (piping, electrical, and sheet metal) field installed by the Contractor and related sleeves, supports, and points of connection specified herein.

C. All unit piping connections shall be fully coordinated with existing to remain piping on roof before unit is installed.

D. Contractor shall provide fully coordinated shop drawing for units to ensure fit of purchased unit with new and existing to remain piping. Design drawings provided have been field measured and replicated within inches of exact unit locations. It shall be the responsibility of the mechanical contractor to ensure new work not shown on the mechanical plans will coordinate with new layout and existing roof items.

PART 2 - Products

2.1 PRODUCT ACCEPTABILITY

A. Provide factory-fabricated and tested custom air handling unit(s) as indicated, of sizes and capacities as scheduled, and as specified herein.

B. The details outlined on the drawings and in the following specification are considered necessary and important by the specifier. Any deviation must be approved by the specifier. The units have been designed to provide appropriate access for service and proper operating clearances, and the dimensions of the units must be strictly adhered to. Under sizing of the housings is unacceptable.

C. Grade “A” units shall be all aluminum construction with no thru metal thermal break and 2 inch foam panel construction. Acceptable manufacturers are: Buffalo, Ingenia, Haakon or York Custom.

2.2 MATERIAL

A. Steel: Galvanized in accordance with ASTM A386 or ASTM A525, G-90 hot dipped, or finished with baked-on enamel; thickness in accordance with USS gages.

B. Aluminum sheet and plate; 3003-H14 alloy, conforming to ASTM 8209.

C. Aluminum Extrusions: 6061-T6 or 6063-T52 alloy, conforming to ASTM B221.

2.3 PERFORMANCE REQUIREMENTS

A. Refer to the equipment schedules for the performance characteristics of all supply fans, coils, humidifiers, filters and related components required in the units.

B. Design data on the equipment schedules refer to conditions at job site elevation.

C. Design fan total static pressures to include all losses, internal and external to the unit.

2.4 GENERAL CONSTRUCTION REQUIREMENTS

A. Custom air handling units shall be factory assembled modules.

B. Design and assemble units to ensure that each enclosure is engineered to withstand 10" WG positive or negative internal pressure, or fan shut-off static pressure, whichever is greater. Leakage shall be no more than 1 % of design air flow.

C. Design and assemble units to require only external connection of electrical power, chilled water, hot water, steam, drain piping, controls and ductwork.
   1. For motor power connections, provide a wire non-fused disconnect switch on the exterior wall of the unit with conduit routed from the motor to the switch.
   2. For floor and condensate drains, provide a floor drain piped through the bottom of the unit. Drains shall be provided at the cooling coils and as indicated on the drawings.

3. Extend piping for each coil and humidifier (if required) 6 inches through panel casing. Terminate piping with either a flange or threaded connection at full size and cap. Provide internal unions for all piping to facilitate removal of coils etc. through access doors.

D. Furnish similar equipment, such as motors, coils, filters, valves, and dampers from the same manufacturer.

E. Factory installs all internal components, conduits, electrical conductors, junction boxes, tubing and piping. All conduits shall be EMT and shall be properly supported and securely attached to units.

F. Removable panels shall be installed and located to facilitate fan and coil removal.

G. Provide floor drains as shown on the drawings. Openings shall be carefully cut and the exposed edges of the insulation protected by steel sleeves continuously welded in place.

H. All conduits penetrating the unit casing shall be sealed airtight. After wire is pulled, Nelson Flame Seal or equal sealant shall be used to maintain airtight casing. Air cannot be transferred into or out of the unit through conduits.

I. Any sheet metal screws placed in unit casing for mounting tubing, conduits, etc., shall be embedded in silicone caulking.

J. All air handling units shall be designed and constructed so that the fan, filters, coils, humidifiers, dampers and access doors are supported from the unit structure framework and not from the unit panels.

K. All casing seams and joints shall be caulked air and water tight with FDA and NFPA 90 approved caulk. Where extrusions intersect, they shall be continuously welded.

L. Piping sleeves shall be provided for all pipes, instrument lines and conduit passing through the casing. All annular spaces shall be sealed, insulation edges shall be sealed.

M. Casing fastening bolts, screws or rivets shall be Type 304 stainless steel.

N. Junction boxes or connectors should be provided at ship break points for electrical and pneumatic connections and shall be properly tagged for reconnection.

2.5 ENCLOSURE CONSTRUCTION

2.6 FRAME AND/OR BASE

A. For Grade “A” units, the unit shall be constructed on all-aluminum or 304 stainless steel structural base. Base shall be designed to support the dynamic load of the unit including 100 MPH wind loads and a snow load of 30 lbs per square ft and prevent any distortion or sagging of units housing, or internal components during lifting, shipping, unloading or operation. Maximum deflection shall not exceed 1/240th of length in either direction.

B. Provide additional structural steel channels and angles to adequately support and secure internal components of unit on no more than 2 foot centers in all directions.

C. The base/floor shall be constructed with adequate stiffening members to prevent oil canning and support a live load of 100 pounds per square foot.

D. Provide each section with a minimum of four lifting lugs attached to the structural components of the unit that are removable.

E. Sealant shall be installed between panels at all joints, between panels and trim, and between panels and base channels to provide an airtight enclosure.

F. Sealant shall be non-sag, non-staining, permanently flexible, of highest quality and recommended by its manufacturer for the intended application.

2.7 FLOORING

A. Flooring shall be of 3/16" thick tread brite aluminum safety plate, continuously welded. The floor shall be fabricated such that each component section within the air tunnel (and each shipping section in other areas) is of pan type construction. The floor plate shall turn up on all sides of the unit and extend upward a minimum of 2" to contain any moisture on the interior of the unit. Sleeves and / or chases through the floor shall extend a minimum of 2" above the surface of the floor and be continuously welded to the floor to maintain a water-tight installation. No drive screws, bolts, or fasteners shall penetrate the unit floor assembly. Caulked and/or gasketed seams are not acceptable.

B. Under-floor shall be insulated with 2" of sprayed-on urethane foam and covered with a 0.040" aluminum sub-floor properly sealed to act as a vapor barrier.

C. Each section shall be provided with a floor drain. The drains shall be factory piped to the unit base rail exterior and capped.

D. Floor drains shall be provided in each section and as indicated on the drawings. Drains shall be a minimum of 2", recessed into the floor and provided with a removable protective grill mounted flush with the floor. Each drain shall be factory piped to the unit exterior with 2" insulated copper pipe and capped.

2.8 DRAIN PANS

A. Full-length drain pans shall be provided for each bank of cooling coils. The pans shall be fully welded 3/16" aluminum tread plate.

B. Where cooling coils are stacked, intermediate drain pans shall be provided. These pans shall be manufactured of 16-gauge Type 304 stainless steel and provided with 1" downspouts of Type 304 stainless steel or Type K copper, draining to the lowest drain pan.

C. Drain pans shall be of the IAQ type and pitched in two directions toward the condensate outlet. The outlet shall be a 1 1/2" minimum Type 304-stainless steel N.P.T nipple extended through the side of the unit base. All pans shall be installed to be completely self-draining. Traps for condensate drains shall be provided and installed by contractor, and shall be sized to assure drainage at the maximum design positive or negative pressure differential.

D. The primary pan shall extend from 6" upstream of the coil assembly to 36” minimum. downstream of the assembly. Intermediate pans shall extend from 4" upstream to 10" downstream of the coil assembly.

E. The primary drain pan shall be a minimum of 3" deep. Intermediate drain pans shall be a minimum of 1" deep.

F. Primary and secondary pans shall extend 1" beyond headers and U-bends on each side of coils.

G. Drain pans meeting the requirements stated above shall be provided in each humidifier section and at the interior of each inlet louver.

2.9 PANEL CONNECTIONS

A. Class “A” units shall have panel connections that use aluminum extrusions with a minimum 3/8" epoxy phenolic resin thermal break incorporated into the extrusions to provide true "no through metal" construction. Units using neoprene or other material less than 3/8" thick to form the thermal break are unacceptable. Where these extrusions meet, they shall be continuously welded for strength and to form an air-tight seal.

2.10 WALLS AND ROOF DECK

A. Class “A” unit casing shall be double wall insulated sandwich panel construction. Outer wall shall be 0.040 inch thick embossed aluminum. Inner walls shall be 0.032" solid aluminum. Insulation for all wall types shall be2 inch polyisocyanurate foam type for walls and roof, having a "U" factor of not less than 0.066 and conforming to NFPA 90 A requirements. Steam coil sections shall have internal fiberglass board insulation.

2.11 ROOF CONSTRUCTION FOR EXTERIOR UNITS

A. Exterior unit roofs shall be either sloped to one side or peaked at 1/8" per foot minimum for proper drainage. The roof shall be designed to with stand loading of 200 lbs. per square foot. Roofing shall be warranted by the manufacturer of the air handling unit for a minimum of 10 years for water tightness and against air bubbles whether from internal leakage or other causes. The air handling unit manufacturer shall verify the airtight integrity of the roof by performing leak testing of the air boundary with soapy water prior to installation of the membrane. Any leaks discovered shall be made leak tight and re-tested.

2.12 ACCESS DOORS

A. Access doors shall be provided in each section. Minimum size shall be 24" wide x 72" high or as high as casing permits. Doors shall be wide enough to remove motors and all other replaceable unit components. Door frames shall be of welded, mitered extruded aluminum with a thermal break and welded at the corners. Door shall be made of insulated sandwich panel construction matching the unit casing construction and thickness. Doors shall be equal to AJ, APEX or Cesco.

B. Doors shall have perimeter airtight double sealing replaceable gasketing. Door sealing gaskets shall be Ventlock No. 380, 3/4 inch wide x 1/8 inch thick sponge rubber.

C. All doors shall have a door latch which shall open from both the inside and outside. The latches shall be Ventlock No. 310 zinc plated. The doors shall be attached to the casing with a continuous stainless steel hinge.

D. All doors shall be installed to open against the higher air pressure.

E. All doors which leak or do not otherwise operate properly shall be repaired or replaced at the Owner's option.

F. All access doors shall be provided with 12" X 12" viewports of double thickness insulated wire reinforced glass.

G. Outside units shall be provided with a 4" rain skirt over each door.

2.13 ACCESS PANELS

A. Removable access panels, located at each coil, fan and where indicated on the drawings shall be provided to facilitate removal of each coil and fan. The panels shall be constructed the same as an access door except that each panel shall be bolted in place on 4" centers.

B. Access panels should facilitate cleaning of coil tubes from exterior of unit without shutting fans down when removable header coils are specified.

2.14 FACTORY INSTALLED COMPONENTS

A. The following components shall be factory installed by the unit manufacturer in full accordance with the component manufacturer's installation procedures.

2.15 FANS AND MOTORS

A. General:
1. Provide fans having a certified rating based on tests performed in accordance with AMCA Bulletins Number 210, 211A and 300. See AMCA Standard 99 "Standard Handbook" for definitions of fan terminology. Arrangement, size and capacity of fans are scheduled on the drawings.
2. All fans shall be statically and dynamically balanced by the manufacturer and shall be provided with field mounted vibration isolation units as hereinbefore specified.
3. Diffuser cones and inlet bells are not permitted in rating a fan unless they are an integral part of the fan design.
4. Provide inlets and outlets of fans not duct connected, including fans in plenum chamber or open to the weather, with heavy guard screens to protect personnel. Construct guard screens in a manner that will not impair fan performance, and when bolted to equipment will permit their removal for fan service and cleaning.
5. Provide lubrication facilities, such as oil reservoirs, sight glasses, grease and relief fittings, fill and drain plugs, pipe connections, etc. Place in a readily and safely accessible location so that after installation they will perform required function without requiring the dismantling of any parts or stopping equipment.
6. All parts of fans shall be protected against corrosion prior to operation of the fan.
7. Certified performance data including acoustical data shall be submitted for each fan at design conditions. Data shall include published sound power levels based on actual test on the fan sizes being furnished, and conducted in accordance with current AMCA standards. Such data is to define Sound Power Levels (PWL), re: 10-12 watts for each of the eight (8) frequency bands. Sound Power Levels shall not exceed those scheduled. Should additional attenuation be required to achieve the levels specified, it shall be included by the fan manufacturer. Any cost of field modifications necessitated by additional attenuation shall also be included by the fan manufacturer. Fan curves shall be submitted which will depict static pressure, total pressure, brake horsepower, and

mechanical efficiency plotted against air volume. Data submitted in tabular form is not acceptable.

8. Motors, drives, curbs, and bases shall be furnished by the fan manufacturer in accordance with the requirements of Section 230513. Motors and drives exposed to the weather shall be suitably protected as specified herein.

2.16 FAN ARRAYS

A. Fan Arrays: Fan arrays shall consist of multiple direct-drive, arrangement 4, modular plenum fans selected to provide the scheduled airflow at the scheduled total static pressure. Fans shall be statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower. Fans shall have a sharply rising pressure characteristic extending through the operating range and continuing to rise beyond the peak efficiency to ensure quiet and stable operation. Fans shall have a non-overloading design with self-limiting horsepower characteristics and shall reach a peak in the normal selection area. All fans shall be capable of operating over the minimum pressure class limits as specified in AMCA's Standard 2408-69.

B. Fans shall be tested in accordance with AMCA 210 and AMCA 300 test standards for air moving devices and shall be guaranteed by the manufacturer to deliver rated published performance levels. [Fans shall be licensed to bear the AMCA certified ratings seal for fan inlet sound, fan outlet sound, and air performance.

C. Fan Housings: Steel frame and panel; fabricated without fan scroll. Shall incorporate a non-overloading type backward inclined airfoil blade wheel. Flat plate blades shall not be acceptable Fans shall be provided with heavy-gauge reinforced steel inlet plate and structural steel frame. Fans shall be provided with inlet screens. Fans shall be provided with a minimum of 2" acoustical insulation. Insulation shall be protected with an erosion resistant vapor barrier preventing insulation shedding for IAQ (indoor air quality).

D. Airfoil, Centrifugal Fan Wheels: Wheels constructed entirely of aluminum to reduce weight and vibration. Airfoil blades shall be extruded aluminum, and continuously welded around all edges. Wheels to be attached to the motor shaft using taper lock bushings or set screws. The wheel and fan inlet are matched and have precise running tolerances for maximum performance and operating efficiency. In addition, fans shall be run tested at the specified operating speed prior to shipment. Each fan shall be dynamically balanced as a complete assembly to achieve Balance Quality Grade G6.3 for the rotating assembly. Maximum vibration shall be within the limits ANSI/AMCA 204 Fan Application Category BV-3. Balance readings shall be taken electronically in the axial, vertical, and horizontal directions. Records of each fan balance shall be made available upon request.

E. Internal Vibration Isolation and Seismic Control:
   1. Fans shall be factory mounted with Neoprene pads.

F. Fan Operations
   1. Each fan shall be equipped with an individual controller, connect back to a unit central mircro-processor. Fan speed and airflow measuring shall be calculated at microprocessor for unit discharge criteria to match design values.

G. Fan Options
   1. Back-Draft Dampers: Each fan shall have an individual industrial grade low leak back-draft damper. Frame shall be minimum 9" deep x 2" (229 x 51) flanged 12 (2.8) gage galvanized steel channel. The blades shall be maximum 7" (178) wide, minimum .080 (2) thick, 6063T5 extruded aluminum airfoil shaped with integral

structural reinforcing tube running full length of each blade. Damper blades shall be equipped with silicone rubber seals mechanically locked into extruded blade slots. Adhesive type seals are not acceptable. Adhesive type seals are not acceptable. Dampers shall be equipped with vinyl jamb seals for low leakage application. Wind stop type seals are not acceptable. Axles shall be minimum 3/4" (19) diameter with machined edge to provide positive locking connection to blades. Full round axles are not acceptable. Bearings shall be ball style pressed into frame. Linkage shall be minimum 3/16" thick 3/4" (5 x 19) bar located on face of blade in airstream. Submittal must include leakage, pressure drop, and maximum pressure data based on AMCA Publication 500 testing.

2. Airflow Measuring: Each fan shall include an Airflow Measuring System (AFMS) consisting of a piezometer ring mounted in the throat and a static pressure tap mounted on the face of the inlet cone. A differential pressure transducer [and an analog display] shall be provided. Transducer shall have a field configurable 0-5 VDC or 0-10 VDC output, as well as a 4-20 mA output. Transducer shall have a standard accuracy of ±1% FS. AFMS shall not obstruct the airflow in any way and shall have no effect on fan airflow performance, static pressure, or sound power levels.

2.17 COOLING, HEATING AND STEAM COILS

A. General
1. All coils shall be certified in accordance with A.R.I. Standard 410 or ASHRAE Standard 33-78 and shall be manufactured by Heat craft or Aerofin.
2. All coils shall have an Electrofin corrosive resistant coating.
3. U-bends shall be formed copper with high temperature silver-brazed joints. Coils over 72" in length shall have a center tube support. Coils over 96" in length shall have two tube supports.
4. Connections to coils shall have thread protectors (caps or plugs).
5. Each coil shall be independently supported by a coil support assembly consisting of a drain pan with integral stainless steel supports mounted on horizontal stainless steel channels and designed such that any coil in a bank can be slid horizontally out of the casing normal to the direction of airflow through the access panel without disturbing the other coils in the bank. When coils are staggered, provisions shall be provided to easily slide the coils furthest from the access panel through the access panel.
   a. Chilled Water Coils
      1) Cooling coils shall be constructed with 5/8" O.D. seamless copper tube with a minimum 0.035" wall thickness. U-bends shall have a minimum 0.035" wall thickness.
      2) Cooling coils shall have minimum 16 gauge #304 stainless steel casings and stainless steel intermediate tube supports.
      3) Coils shall be of the continuous plate fin type with 0.0075" thick copper fins. Fin spacing shall not exceed 10 fins per inch.
      4) Headers shall be 0.049" thick copper pipe with brazed joints. Headers shall be provided with plugged drain and vent openings at the highest and lowest points in the coil.
      5) Coil connections shall be schedule 40 red brass pipe with threaded connections, the connections shall be factory piped through the casing wall with a minimum extension beyond the casing exterior of 2.5 times the pipe O.D.,internal unions shall be provided.
      6) Safing for the cooling coils shall be 16-gauge Type 304 stainless steel.
      7) Coils shall be suitable for operation at 200 PSIG and 220 F and shall have been tested with minimum air pressure of 250 PSIG while coil is under water.
   b. Hot Water Coils

1) Hot water and energy recovery coils shall be constructed similar to cooling coils, but with 6- ga. galvanized casings, hot-dip galvanized coil supports, and galvanized safing

c. Steam Coils

2) Steam distributing coils shall be operable at 50 psig pressure and a corresponding saturated steam temperature of 298° F. Factory test steam coils with 325 psig compressed air under water. Dehydrate and seal coils prior to shipping.

3) Provide steam-distributing coils with a tube outer diameter (OD) of 1" and an inner distribution tube of 5/8" O.D and wall thickness of 0.035". Circuit coils for gravity drain of condensate without trapping. Steam shall discharge in the direction of condensate flow to ensure even heat transfer across each tube.

2.18 FILTERS AND FILTER FRAMES

A. Air filters shall be Cambridge, Farr, or American Air Filter equal to the filters specified herein. Air filter capacities and bank sizes shall be as scheduled on the drawings.

B. Type "A" Filter Elements: F-1-1

1. Air filters shall be Farr 30/30 or approved equal. Each filter shall consist of a cotton and synthetic media, support grid, and enclosing frame. The filter shall be listed by Underwriters' Laboratories as Class 2.
2. Filter media shall have an average efficiency of twenty-five (25) to thirty (30) percent and an average arrestance of ninety (90) to ninety-two (92) percent in accordance with ASHRAE Test Standard 52.
   a. AHUs 4 inch filter face area shall contain not less than three (3) pleats per linear meter with an initial resistance at 500 feet per minute shall not exceed 0.25IWG water gauge.
   b. Filters for energy recovery coils. 2 inch filter face area shall contain not less than five (5) pleats per linear meter with an initial resistance at 500 feet per minute shall not exceed 0.25IWG water gauge. Pre filters to filters "C".
3. Media support grid shall be welded wire on one (1) inch centers with an open area of not less than ninety-six (96) percent. Grid shall be bonded to the media to eliminate oscillation and pull away. The grid shall be formed to effect a radial pleat, allowing total use of media.
4. Enclosing frame shall be a rigid, high wet-strength beverage board, with diagonal support members bonded to the air entering and air exiting side of each pleat. The enclosing frame shall be chemically bonded to the filter pack.

C. Type "B" Filter Elements: F-1-2

1. Air filters shall be Filtration Group Aerostar FP mini pleat V-Bank high performance Merv 16 99% efficient, deep pleated, totally rigid and totally disposable type. Each filter shall consist of high density media, media support grid, contour stabilizers, diagonal support bracing and enclosing frame. Provide 2 inch Type "A" filters as pre filters to the Type "B" filter.
2. Filter media shall be of high density wet laid microglass fibers. The filter media shall have an average efficiency of ninety-nine (99) percent on the ASHRAE Test Standard (52-76). It shall have an average arrestance of not less than ninety-nine (99) percent on that standard. Filters shall be listed by Underwriters' Laboratories as Class 2.
3. Media support grid shall be welded wire grid with an effective open area of not less than ninety-six (96) percent. The welded wire grid shall be bonded to the filter media to eliminate the possibility of media oscillation and media pullaway. The media support grid

shall be formed in such a manner that it effects a tapered radial pleat design. The grid shall be designed to support the media both vertically and horizontally.

4. Contour stabilizers shall be composite material and shall be permanently installed on both the air entering and air exiting sides of the filter media pack to insure that the tapered radial pleat configuration is maintained throughout the life of the filter. There shall be four contour stabilizers on the air entering side and six on the air exiting side. The filter shall be capable of withstanding 10 IWG water gauge pressure drop without noticeable distortion of the media pack.
5. The enclosing frame shall be constructed of composite material. It shall be assembled in such a manner that a rigid and durable enclosure for the filter pack is effected. The media pack shall be mechanically and chemically bonded to the inside periphery of the enclosing frame, thus eliminating the possibility of air bypass. The enclosing frame shall be equipped with galvanized steel protective diagonal support braces on both the air entering and air exiting sides of the filters. The diagonal support braces shall be mechanically fastened to each contour stabilizer.

D. Type "A" Filter Holding Frame:
1. Holding Frame shall be Farr Type 8 or approved equal. Frames shall be constructed of not less than sixteen (16) gauge galvanized steel and be equipped with polyurethane foam gaskets, fasteners and filter centering dimples. The four sealing flange corners shall be flush mitered and secured in order to form a uniform sealing and gasketing surface. The in-line depth shall be not less than 30 inches in order to effect adequate bearing surface for built-up filter banks. Filter fasteners shall be capable of being installed without the requirement of tools nut or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fasteners. Provide all required fastener for the initial installation and turn fifty (50) percent spare fastener of each type over to the owner for future use.
2. Filter banks with elements over three (3) high or three (3) wide shall be braced with vertical stiffeners riveted or bolted between the individual holding frames. Perimeter area of holding frames shall be safed off using sixteen (16) gauge galvanized steel. Caulk airtight all around perimeter of holding frames, safing, and between individual holding frames.

E. For each filter bank, provide a Dwyer Model 2001-AF magnahelic air filter gauge complete with static pressure types, tubing, and accessories. Mount gauge on exterior of unit casing.

F. Capacities, efficiencies, and size of filter units shall be as scheduled on the drawings. Provide each filter assembly with a complete spare set of prefilters and final filters.

2.19 DAMPERS

A. Aluminum Low Leakage Dampers
1. Frame shall be 5" x 1" x aluminum hat channel with corner braces.
2. Blades shall be airfoil shaped, double skin construction of 14 gauge equivalent thickness, maximum 6" wide, opposed blade, as detailed on the drawings.
3. Assembly shall use extruded vinyl blade edge seals and flexible metal compressible jamb seals. Shafts shall be square or hexagonal. Round shafts are unacceptable.
4. When tested in accordance with AMCA Standard 500, leakage rate through a 48" wide damper shall not exceed 6.2 CFM/sq. ft. @ 4" W.G.
5. Dampers shall be Ruskin or equal.

B. Smoke Dampers
1. Smoke dampers that do not serve as fan isolation dampers shall be Ruskin SD-50 or equal.

2. Frame shall be 5" x 1" x 6063T5 extruded aluminum hat channel with .125" minimum wall thickness.
3. Blades shall be maximum 6" wide 6063T5 heavy gauge extruded aluminum, airfoil shape, parallel blade, as detailed on the drawings.
4. Dampers shall have silicon rubber blade edge seals and flexible aluminum compression type jamb seals.
5. The leakage rating under UL555S shall be Leakage Class I. W.G. pressure differential.
6. Dampers shall be furnished with electric actuators.

C. Damper Operators
1. Damper actuators (except for smoke dampers) shall be furnished by the ATC contractor and installed by the unit manufacturer.
2. Damper actuators shall be provided and installed by the air handling unit manufacturer.
3. All dampers shall be 120 volt.

2.20 HUMIDIFERS

A. Humidifier Steam Manifold/Dispersion Panel
1. Provide and factory mounted Short Absorption Manifold (Humidifier Steam Dispersion Panel). Short Absorption Manifold is designed to distribute pressurized steam from a facility steam boiler, to directly inject the steam into Air handling unit for humidification.
   a. Absorption distance characteristic shall prevent water accumulation on any induct surfaces beyond 12 in downstream of the steam dispersion panel.
   b. Steam dispersion panel consisting of a (one) horizontal 304 stainless steel round header supplying steam to a bank of closely spaced 12” vertical tubes, as necessary to meet absorption distance requirements, and to reduce condensation losses.
   c. Steam inlet and condensate return located on the same side and at the bottom of the header to allow single point entry and floor mounting.
   d. Vertical stainless steel distribution tubes to promote condensate evacuation. Horizontal distributor tubes are not acceptable.
   e. Distribution tubes shall include threaded standoffs for trouble free attachment to factory- supplied support bracket.
   f. All tubes are 304 stainless steel construction. 409 stainless steel header and distribution tubes are not acceptable.
   g. Stainless steel nozzle inserts ensure condensate free steam is discharged from the center of the distribution tubes. Systems without nozzle inserts, or other than stainless steel, are not acceptable.
   h. Stainless steel nozzle inserts shall have metered orifices, sized to provide even distribution of the discharged steam, spaced for optimum steam absorption.
   i. The SAM-e header functions as an internal steam separator, therefore an external Steam separator is not required.
   j. Provide adjustable 304 stainless steel mounting frame.
   k. Tubes and headers shall accommodate factory installation or field retrofit of optional insulation for increased energy efficiency.
2. Ship Loose Items
   a. Provide steam control valve with electrical actuator normally closed, spring return (24V), steam control valve with equal percent flow characteristics and positive shut off against steam. Control valve shall be compliant with ANSI B 16.15 class 250 pressures and temperature rating B 16.104 class IV control shut off leakage and ANSI/ISA-575.11 flow characteristics standards. Steam control valve to be Stainless Steel body with Stainless Steel seat, stem and plug.
   b. Stainless Steel steam traps and Stainless Steel wye strainer.
   c. Air Proving switch.

2.21 SOUND ATTENUATORS

A. Sound attenuators shall be constructed of 22-gauge galvanized outer shell, 24-ga. perforated galvanized inner shell, and 24-ga. perforated galvanized baffles. Seams shall be lock formed and mastic filled. Attenuators shall be equal to SEMCO, IAC or Vibro Acoustics.

B. Non-erosive filler material shall be glass fiber of a density sufficient to obtain the specified acoustic performance and packed under at least 5% compression to eliminate voids due to vibration and settling. Material shall be inert, vermin, and moisture proof.

C. Silencers shall not fail structurally when subjected to a differential air pressure of 10" W.G. inside to outside of casing.

D. Sound attenuators acoustical performance shall meet or exceed that scheduled on the drawings, and shall be independently certified by a nationally recognized testing laboratory in accordance with ASTM E-477-90.

E. Sound attenuator self-generated noise shall not exceed that scheduled on the drawings.

F. Attenuators shall exhibit not more than the following fire hazard classification values when tested in accordance with ASTM-E84, NFPA 255 or UL-723 test methods:

Flame spread Classification:	20
Smoke Development:	20
Fuel Contributed:	15

G. Static pressure drops through the attenuators shall not exceed those indicated on the drawings. Airflow and pressure loss data taken in accordance with AMCA procedures shall be obtained from the same silencer used for acoustic performance tests.

H. Where indicated on the drawings, the fill material shall be encapsulated with Mylar to eliminate carryover of inorganic particulate matter from the attenuator and reduce the adsorption of gases and/or entry of Brownian particles into the fill. The attenuator shall be provided with an access panel to allow the fill to be removed and permit the cleaning of all exposed and concealed surfaces.

2.22 AIRFLOW MEASURING STATIONS

A. Fan Inlet Airflow Measuring Devices
   1. Fan inlet airflow measuring devices shall be Air Monitor Volu-probe/FI airflow traverse probes. The probes shall contain multiple total and static pressure sensors at concentric area centers along the exterior surface of the probe and internally connected to their respective averaging manifolds.
   2. Sensors shall not protrude beyond the surface of the probe, nor be adversely affected by particle contamination normally present in building system airflows.
   3. The fan inlet airflow traverse probes (two per inlet) shall have dual end support brackets suitable for mounting in the fan inlet bell and symmetrical averaging signal takeoffs and fittings. Probes for fan inlets 20" in diameter and larger shall be extruded aluminum with hard anodized finish. Probes for smaller fan inlets shall be 300 series stainless steel.
   4. The fan inlet airflow traverse probes shall not induce a measurable pressure drop, nor shall the sound level within the system be amplified by its presence in the fan inlet bell. The probes shall be capable of producing steady, non-pulsating signals of standard total and static pressure, without need for flow corrections or factors, with an accuracy of 3%of actual flow over a fan operating range of 6 to 1 capacity turndown.

B. Transmitters

1. Electronic flow transmitters shall be capable of receiving signals of total and static pressure from the airflow measuring device, of amplifying, extracting the square root, and scaling to produce a 4-20 maDC or 0-5 VDC output signal linear and scaled to air volume or velocity. Flow transmitters shall be of the industrial process control type. Commercial grade transmitters are not acceptable.
2. Transmitters shall include an adjustable (every 1 to 24 hours on 1 hour intervals) automatic zeroing circuit and be capable of maintaining linear output signals on applications requiring 10 to 1 velocity (100 to 1 pressure) turndown. The transmitter shall include an integral multi-line digital LED display for configuration and calibration, and to display one transmitter output during normal operating mode. Input pushbuttons shall provide means to perform transmitter configuration, parameter setting, zero and span calibration, and display formatting and scaling via the on-board microprocessor. Transmitters shall be Air Monitor Veltron II in NEMA 1 enclosure and enclosed terminal strip, in compliance with the following criteria:

Reference Accuracy:	± 0.25% of natural span (including non-linearity, hysteresis, and non-repeatability)
Zeroing:	Automatic, within 0.1% of operating span
	Spans:
	Factory custom spanned down to 40% of natural spans. Natural span ranges from 0 to 400 FPM to 0 to 12665 FPM.
Temperature Stability:	0.015% of full span/F. No zero effect.
Power Supply:	24 VAC, 20 to 40 VDC, selectable.
	Optional 120 V AC
Overpressure Limit:	25 psig

2.23 VARIABLE FREQUENCY DRIVES (REFER TO DIVISION 26 FOR REQUIREMENTS)

B. All air handling units shall be provided with unit mounted variable frequency drives (VFDs). Coordinated quantity of VFDs with specified unit. Contractor to coordinated field measurements of existing to remain items on roof to ensure new unit mounted VFDs have required clearances. Contractor is responsible for ordering the unit with coordinated locations of externally mounted VFDs. VFD’s shall be rated for exterior installations and have a minimum NEMA 3R rating for wet environments.

2.24 ELECTRICAL

A. General

1. All electrical wiring shall be in conformance with the N.E.C.
2. All wiring shall be 600 volt rated type M1W/THWN stranded copper, enclosed in 3/4-inch diameter or larger, EMT galvanized conduit. Connections to all fans shall be made with a minimum 3-foot length of 3/4-inch diameter or larger liquitite flexible conduit. All junction boxes shall be U.L. approved and gasketed.
3. All wiring shall be routed above access doors and panels and shall be not less than 12" above the unit interior floor.
4. On units that ship in sections, wiring harnesses shall be provided for facilitate field reconnection at section breaks.
5. All permanent and temporary conduit termination points shall be sealed to prevent moisture from entering the conduit.

6. All control and instrument wiring shall be identified with a unique wire number. These numbers shall agree with the numbers shown on the supplier's wiring diagrams. Control circuit wiring shall be permanently identified with W. H. Brady Company wire markers applied within 1" of each terminal and splice.

    a. Power Wiring

        1) Unit shall be completely factory wired and shall be arranged to accept a single point 3 phase 460 volt power connection to a factory installed and wired, main non-fused unit disconnect. Unit manufacturer shall furnish, install and wire, a main load distribution panel board with branch circuit automatic trip circuit breakers equivalent to Cutler Hammer Pow-R-Line C; a mini power center with a primary main automatic trip circuit breaker, encapsulated dry type transformer, secondary main automatic trip circuit breaker, automatic trip feeder circuit breakers for each circuit and two 20 Amp automatic trip circuit breakers to be used as spares. The mini power center shall be equivalent to Cutler Hammer.
        2) Unit manufacturer shall factory wire all fan motors through non-fused service disconnects located adjacent to the motors to junction boxes. Internal Note: service disconnects adjacent to the motors are not required when the distribution panel or VFD serving the motor can be pad-locked in the open circuit position, still, many operations managers require them since they afford the best protection for their personnel. Factory installed and wired motor starters.
        3) Unit manufacturer shall factory wire all energy recovery wheel motor and wheel controls, lighting and receptacle circuits, and all other electrical components to electrical main load distribution panel board or mini power center as applicable.
        4) Lighting and control circuits shall remain functional when main disconnect is in "Off position.

    b. Lighting Systems and Receptacles

        1) Each unit shall have factory installed and wired lighting fixture in each compartment, placed for optimum viewing without obstructing service access.
        2) Lights shall be wired through light switches with timers at each section access door to a central lighting junction box for field connection of 120 volt power supply.
        3) Lighting fixtures within the entire unit shall be four foot long two tube T8, 40 Watt, gasketed outdoor grade vapor proof fluorescent with rapid start low temperature electronic ballasts. Fixtures shall be equivalent to Metalux Model VF240DR.
        4) Weatherproof duplex GFI receptacles shall be provided at fan and filter sections and elsewhere as detailed on the drawings. Receptacles shall be factory wired to the factory installed and wired mini power center.
        5) Exterior fixtures shall be LED weatherproof fixtures factory mounted and wired to the lighting junction box the factory installed and wired mini power center. Lights shall be controlled through factory installed weatherproof switch. Lights shall be removed prior to shipment to prevent shipping damage and shall be remounted by the Contractor.

B. Equipment Identification

1. Mechanical and electrical equipment within the unit shall be identified in accordance with the designations indicated on the drawings using engraved laminated black and white phenolic leg-end plates. Letters shall be 3/4" high black on surrounding white and mounted using non-ferrous screws.

PART 3 - EXECUTION

3.1 GENERAL

A. It is the responsibility of the mechanical contractor to coordinate the final and actual dimensions of the air handling units before purchase to ensure they can be installed in the allotted spacing. Contractor to verify and confirmed right and left hand coils connections, access door swings piping space requirements, etc…Since there is limited space on the roof the mechanical contractor shall also verify new unit dimensions with all existing to remain items and equipment, not limited to mechanical and electrical equipment, structural members, equipment bracing, stands. All clearances must be verified for existing equipment and new equipment before start of work to ensure new units can be installed to meet the manufacturer's requirements.

3.2 FACTORY INSPECTION AND TESTING

A. Prior to shipment to the project, each unit shall be inspected, tested, and, in the judgment of the project consultant, determined to be in compliance with the specifications. Any deviations found shall be corrected. The Owner and/or Owner's representative(s) may, at their option, inspect the equipment and witness the testing. The cost of travel and accommodations for three persons shall be at the unit manufacturer's expense. The unit manufacturer shall provide notification two weeks prior to the date the unit(s) will be ready for inspection and testing. The following tests shall be performed:
   1. Air Leakage Test
      a. The unit housing shall be tested for leakage at the greater of 10" W.G. differential pressure or 1.5 times the design operating static pressure, positive or negative depending on unit configuration.
      b. SMACNA HVAC Duct Leakage Manual. Leakage rate shall not exceed 1 percent of design airflow. Testing shall be done on the assembled unit, with openings sealed as required to isolate the positive and negative pressure sides of the unit.
      c. Submit for review and approval 10 days prior to the performance of the of the testing either flow meter calibration data or certification signifying that the manufacturer of the meter is incompliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.
      d. A minimum of 10 working days prior to the air leakage test, the air handling unit manufacturer shall submit copies of the Air Leakage Test Form, provided as part of this specification, properly filled out, for each unit to be tested, and submitted for the engineer's review and approval. The factory testing shall not occur without the engineer's approval of the test form. After successful completion of the test, two (2) copies of the complete report shall be submitted to the engineer for final acceptance.
      e. If the specified leak rate is not attained, the unit manufacturer shall modify the unit in any and every manner required to achieve the required results except that the modifications shall not compromise the unit construction, performance, or any other elements of the unit deemed important to the design consultant. After the modifications are complete, the manufacturer shall retest the unit at their expense, in the presence of the owner or its representatives. All costs involved in bringing the consultants back to the factory, including payment of the consultant's hourly fee will be borne by the unit manufacturer.
   2. Airflow Test
      a. A coil face traverse as per ASHRAE TP 3359 shall be performed. Testing shall be performed using a rotating vane anemometer. (38) Velocity readings shall be taken on the downstream side of a dry coil. A variable plug shall be used to induce the specified operating static pressure. Air-flow shall be calculated from the

velocity readings corrected for air density and applying a K-factor described in ASHRAE TP 3359.

b. Discharge side or suction side ductwork shall be attached to each unit, a duct traverse shall be taken to confirm performance airflow.

3. Fan Vibration Test
   a. All fan assemblies shall have a dynamic balance performed after the unit is complete. An IRD or PMC analyzer shall be used to measure velocity. The final reading shall not exceed 0.1 inch per second vertically or horizontally at the bearing caps nor exceed 0.09 inches per second in the axial direction. The exact level of vibration shall be recorded operation and maintenance manual as proof of the factory dynamic balance.
4. Piping Test
   a. Piping systems and coils shall be hydrostatically or pneumatically pressure tested at one and one-half times the maximum operating pressure.
5. Panel Deflection Test
   a. A panel deflection test shall be performed. The testing shall be performed with a dial indicator accurate to plus or minus 0.001". The cabinet panel deflection shall not exceed 1/200 of the panel span at the casing leakage test pressures.
6. Run Test
   a. Each unit shall be factory run-tested prior to shipment. All electrical and pneumatic components shall be operated to assure operational integrity, including:
      1) Fan systems
      2) Adjustable frequency drives
      3) Energy recovery systems
      4) Humidification systems
      5) Dampers and damper operators
      6) Control systems (where applicable)
      7) Lightning systems
      8) Power wiring
   b. A written certification of the run-test shall be provided in the 10M manuals.

3.3 WARRANTY

A. The unit manufacturer shall warrant parts and workmanship for one year from the date of equipment start-up. During this warranty period, the manufacturer will provide replacement parts as required to return the unit to operation.

B. Warranty covers all parts except consumable items (belts, filters, fuses) for the warranty period. It does not cover refrigerant (if applicable). It does not cover any labor to troubleshoot machinery or install parts or normal maintenance and re-calibration labor after initial field start-up.

3.4 SUPERVISION OF INSTALLATION

A. The manufacturer's factory trained and authorized technician shall supervise the work performed by the installing contractor during the rigging and assembly of the unit (s). All tools and labor, shall be provided by the installing contractor.

3.5 SYSTEM CHECK TEST AND START-UP

A. Unit start-up shall be performed by the installing contractor under the supervision of a factory trained and authorized technician.

3.6 USER TRAINING

1. The manufacturer's agent shall provide a minimum of 40 hours of training on the proper operation and maintenance of the unit. The operator training shall be video taped by the manufacturers agent, and a copy provided to the Owner's representative as a training reference.

3.7 CONTRACTOR COMMISSIONING

A. After final assembly is complete, each unit shall be inspected and tested in the field, by the installing contractor, and shall be determined to be in compliance with the specifications. Any deviations found shall be corrected. The Owner and/or Owner's representative(s) may inspect the equipment and witness the inspection and testing. The installing contractor shall provide notification one week prior to the date the unit(s) will be ready for inspection and testing.

B. The following tests shall be performed by the installing contractor:
1. Air Leakage Test
2. The unit housing shall be tested for leakage at the greater of 10" W.G. differential pressure or 1.5 times the design operating static pressure, positive and/or negative depending on unit configuration.
3. The manufacturer of the air-handling unit shall suitably seal all factory penetrations in the casing sections to be air leak tested prior to shipment. This includes, but is not limited to, all factory supply/return/exhaust/outside air openings, pipe sleeves, pipe and electrical chases, floor drains, condensate drain lines, etc. The unit manufacturer shall provide appropriately sized and sealed connections (minimum 2" collar) at each casing section to be t installing contractor shall suitable seal all non-factory penetrations made to the air-handling unit casing in the field.
4. The leakage test shall be conducted in accordance with the procedure outlined in the SMACNA HVAC Duct Leakage Manual. Leakage rate shall not exceed 1% of design air-flow. Testing shall be done on the assembled unit, with all openings sealed, as required to isolate the positive and negative pressure sides of the unit.
5. Contractor shall submit for review and approval, 10 days prior to the performance of the testing, either flow meter calibration data or certification signifying that the manufacturer of the meter is in compliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.
6. The Air Leakage Test Form, provided as part of this specification, shall be properly filled out and submitted to the engineer, for each unit to be tested, 10 working days in advance of the performance of the testing for the engineer’s review and approval. The field testing shall not occur without the Engineers approval of the Test Form. After successful completion of the test, two (2) copies of the complete report shall be submitted to the engineer for final acceptance.
7. If the leakage rate exceeds that specified, the installing contractor shall make the necessary modifications to the unit and retest the unit at his own expense until the specified leak rate is delivered.
8. The unit manufacturer shall provide, a test fan, full freight allowed to the project site, of sufficient capacity to provide the necessary CFM at the required positive and/or negative static pressure and test instrumentation. The installing contractor shall provide, temporary high pressure duct material between the test fan and the unit(s) to be tested, all field labor, which includes but is not limited to: off loading and rigging of the test equipment into position, installation, prior to the test, and removal, after the test, of the unit connection fittings and temporary duct material, providing a 460 volt/3 phase temporary electric circuit sized to power the test fan within 6 feet of the test fan and a 115 volt/1 phase temporary electric service at each unit to be tested, labor and materials required to re-turn the test equipment (freight collect) to the air handling unit manufacturer and all other items required to perform successful testing.
9. Fan Vibration Test

a. All fan assemblies shall have a dynamic balance performed after the unit is complete. An IRD or PMC analyzer shall be used to measure velocity. The final reading shall not exceed 0.1 inch per second vertically or horizontally at the bearing caps nor exceed 0.09 inches per second in the axial direction. The exact level of vibration shall be recorded operation and maintenance manual as proof of the factory dynamic balance.

3.8 INSTALLATION

A. General
1. Contractor to install air handling units where indicated on the drawings in full accordance with equipment manufacturer's installation instructions and as follows:
   a. Access: Provide access space around units for service as indicated on the drawings, but in no case less than recommended by the equipment manufacturer.
   b. Electrical: Install electrical devices furnished by unit manufacturer but not specified to be factory -mounted. Verify that electrical wiring installation is complete and in accordance with manufacturer's submittal and installation requirements of Division 16 sections.
   c. Piping: Provide piping, valves, accessories, gauges, and supports as indicated on the drawings. Trap unit drain pans according to manufacturer's recommendations and extend condensate line to nearest drain. For indoor units, provide a concrete pad of adequate height to allow for proper installation of condensate drain trap above the finished floor.
   d. Duct Connections: Provide ductwork, accessories, and flexible connections as required.

3.9 FINAL CLEANING

A. Prior to acceptance by the owner, the contractor shall thoroughly clean the outside and particularly the inside of each air handling unit. Industrial grade cleaners can be used to remove construction dust. Any sheet metal mil finish or grease can be removed with Freon TF solvent fluorocarbon. All proposed cleaning materials shall have contents identified and approved prior to use.

AIR LEAKAGE TEST FORM

The items below are to be submitted to the engineer 10 working days in advance of the performance of the leak testing for engineer's review and approval. Testing is not to occur prior to engineer's approval.

Project Name:
Date of Test:
Unit Manufacturers Name:
Unit Project Tag:
Unit Model Number:
Unit Serial Number:

Positive Pressure Test
Total design CFM to be used for basis of positive pressure leakage determination:
The positive pressure at which the casing will be tested:
Maximum allowable CFM leakage - positive (ex. 60,000 design CFM @ 1% leakage = 600 CFM):

Negative Pressure Test
Total design CFM to be used for basis of negative pressure leakage determination:
The negative pressure at which the casing will be tested:
Maximum allowable CFM leakage - negative: (ex. 60,000 design CFM @ 1 % leakage = 600 CFM):

The largest casing volume to be tested during positive or negative pressure test:
The CFM output of the test fan at the maximum design test pressure:
Submit copy of fan curve for the test blower for engineers review and approval.
Estimated time to achieve test pressure (casing volume tested 1 fan CFM - max leakage CFM):

Flow orifice Manufacturer:
Flow orifice Model Number:
Flow orifice Serial Number:
Flow orifice calibration Date:
Diameter of flow orifice (D2):
Duct Connection Size (D1):
Ratio D21 D1:
Orifice coefficient (K from Table 5-1):

Flow Equation (equation #1)

The delta P across the flow orifice, which relates to the maximum allowable CFM leakage positive:
The delta P across the flow orifice, which relates to the maximum allowable CFM leakage negative:

This form must be accompanied with either flow meter calibration data or certification signifying that the manufacturer of the flow meter is in compliance with the ASME Requirements for Flow Meters per section 5.3 of the SMACNA HVAC Duct Leakage Manual.

Readings taken during Field Testing

	Positive Pressure	Negative Pressure
Pressure		
The casing pressure reading taken during the		

test:
The delta P reading taken across the flow orifice:
The calculated casing CFM leakage:
The casing tested leak rate (%):

Testing Performed By:	Name	Company	Signature
Testing witnessed By:	Name	Company	Signature
Test Results:	Passed	Failed - Must Retest	Per Signature:

END OF SECTION 237330

SECTION 238216.11 - HYDRONIC AIR COILS

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 hydronic heating and cooling air coils.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil.
   2. Include rated capacities, operating characteristics, and pressure drops for each air coil.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which coil location and ceiling-mounted access panels are shown and coordinated with each other.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.6 FIELD CONDITIONS

A. Altitude above Mean Sea Level: 13 feet.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. ASHRAE Compliance: Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

2.2 COILS

A. All water coils exposed to seawater environment shall have electrofin corrosion resistant coating.

B. Manufacturers: Subject to compliance with requirements, provide products by the following:

C. Water coils Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
1. Aerofin.
2. Carrier Corporation; a UTC company.
3. Coil Company, LLC.
4. Colmac Coil Manufacturing, Inc.
5. Dunham-Bush USA.
6. Heatcraft Worldwide Refrigeration.
7. Greenheck Fan Corporation.
8. Super Radiator Coils.
9. Trane.
10. USA Coil & Air.

D. Steam Integral Face and bypass (IFB) coils Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Wing.
2. Control Air.

E. Performance Ratings: Tested and rated according to AHRI 410 and ASHRAE 33.

F. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.

G. Source Quality Control: Factory tested to 300 psig.

H. Tubes: ASTM B 743 copper, minimum 0.020 inch thick.

I. Fins: Copper, minimum 0.006 inch thick.

J. Headers: Seamless copper tube with brazed joints, prime coated.

K. Frames: Galvanized-steel channel frame, minimum 0.052 inch thick for flanged mounting.

L. Hot-Water Coil, Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
1. Coil Configuration: Horizontal tubes.
2. Dampers: Extruded-aluminum blades with edge and end seals; full-length drive rod and mount for actuator outside the airstream.

M. Coil Capacities and Characteristics:
1. Minimum Fin Spacing: 0.125 inch.
2. Tube Diameter: 0.375 inch.
3. Number of Rows: 2 row minimum.
4. Mounting: Flanged.
5. Coating: Electrofin corrosion resistant coating.
6. Air Side:
   a. Refer to Mechanical Schedules for details.

7. Water Side:
   a. Refer to Mechanical Schedules for details.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

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

3.2 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Install stainless-steel drain pan under each cooling coil.
   1. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1.
   2. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
   3. Extend drain pan upstream and downstream from coil face.
   4. Extend drain pan under coil headers and exposed supply piping.

D. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.

E. Straighten bent fins on air coils.

F. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

G. All steam coil connections shall be

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to coils to allow service and maintenance.

C. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Section 230900 "Instrumentation and Control for HVAC," and other piping specialties are specified in Section 232116 "Hydronic Piping Specialties."

END OF SECTION 238216.11

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Copper building wire rated 600 V or less.
2. Connectors, splices, and terminations rated 600 V and less.

1.3 DEFINITIONS

A. RoHS: Restriction of Hazardous Substances.

B. VFC: Variable-frequency controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Product Schedule: Indicate type, use, location, and termination locations.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For testing agency.

B. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA.

1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PRODUCTS

2.1 COPPER BUILDING WIRE

A. Description: Flexible, insulated and uninsulated, drawn copper current-carrying conductor with an overall insulation layer or jacket, or both, rated 600 V or less.

B. Standards:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
2. RoHS compliant.
3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."

C. Conductors: Copper, complying with ASTM B3 for bare annealed copper and with ASTM B8 for stranded conductors.

D. Conductor Insulation:

1. Type RHH and Type RHW-2: Comply with UL 44.
2. Type USE-2 and Type SE: Comply with UL 854.
3. Type TC-ER: Comply with NEMA WC 70/ICEA S-95-658 and UL 1277.
4. Type THHN and Type THWN-2: Comply with UL 83.
5. Type THW and Type THW-2: Comply with NEMA WC-70/ICEA S-95-658 and UL 83.
6. Type UF: Comply with UL 83 and UL 493.
7. Type XHHW-2: Comply with UL 44.

E. Shield:

1. Type TC-ER: Cable designed for use with VFCs, with oversized crosslinked polyethylene insulation, spiral-wrapped foil plus 85 percent coverage braided shields and insulated full-size ground wire, and sunlight- and oil-resistant outer PVC jacket.

2.2 CONNECTORS AND SPLICES

A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.

B. Jacketed Cable Connectors: For steel and aluminum jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.

C. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.

1. Material: Copper.
2. Type: One hole with standard barrels.
3. Termination: Compression.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper; solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway

B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN/THWN-2, single conductors in raceway.

C. Exposed Branch Circuits: Type THHN/THWN-2, single conductors in raceway.

D. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway.

E. VFC Output Circuits: Type XHHW-2 in metal conduit

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 260533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

F. Support cables according to Section 260529 "Hangers and Supports for Electrical Systems."

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-486B.

B. Make splices, terminations, 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 of slack.

3.5 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 260553 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.6 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.7 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 078413 "Penetration Firestopping."

3.8 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

C. Perform tests and inspections with the assistance of a factory-authorized service representative.

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.

2. Perform each of the following visual and electrical tests:

    a. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
    b. Test bolted connections for high resistance using one of the following:

        1) A low-resistance ohmmeter.
        2) Calibrated torque wrench.
        3) Thermographic survey.

    c. Inspect compression-applied connectors for correct cable match and indentation.
    d. Inspect for correct identification.
    e. Inspect cable jacket and condition.

f. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
g. Continuity test on each conductor and cable.
h. Uniform resistance of parallel conductors.

3. Initial Infrared Scanning: After Substantial Completion, but before Final Acceptance, perform an infrared scan of each splice in conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner. Correct deficiencies determined during the scan.

   a. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
   b. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

4. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Substantial Completion.

D. Cables will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 260519

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. Section Includes:

1. Steel slotted support systems.
2. Conduit and cable support devices.
3. Support for conductors in vertical conduit.
4. Structural steel for fabricated supports and restraints.
5. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
6. Fabricated metal equipment support assemblies.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for the following:

a. Slotted support systems, hardware, and accessories.
b. Clamps.
c. Hangers.
d. Sockets.
e. Eye nuts.
f. Fasteners.
g. Anchors.
h. Saddles.
i. Brackets.

2. Include rated capacities and furnished specialties and accessories.

B. Shop Drawings: For fabrication and installation details for electrical hangers and support systems.

1. Hangers. Include product data for components.
2. Slotted support systems.
3. Equipment supports.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.

C. Delegated-Design Submittal: For hangers and supports for electrical systems.

1. Include design calculations and details of hangers.
2. Include design calculations for seismic restraints.

1.4 QUALITY ASSURANCE

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

1. AWS D1.1/D1.1M.
2. AWS D1.2/D1.2M.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design hanger and support system.

B. Seismic Performance: Hangers and supports shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.

1. The term "withstand" means "the supported equipment and systems will remain in place without separation of any parts when subjected to the seismic forces specified and the supported equipment and systems will be fully operational after the seismic event."
2. Component Importance Factor: 1.5.

C. Surface-Burning Characteristics: Comply with ASTM E84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame Rating: Class 1.
2. Self-extinguishing according to ASTM D635.

2.2 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.
2. Material for Channel, Fittings, and Accessories: Galvanized steel.
3. Channel Width: Selected for applicable load criteria.
4. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

B. Aluminum Slotted Support Systems: Extruded-aluminum channels and angles with minimum 13/32-inch-diameter holes at a maximum of 8 inches o.c. in at least one surface.
1. Standard: Comply with MFMA-4 factory-fabricated components for field assembly.

2. Channel Material: 6063-T5 aluminum alloy.
3. Fittings and Accessories Material: 5052-H32 aluminum alloy.
4. Channel Width: Selected for applicable load criteria.
5. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
6. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.

C. Conduit and Cable Support Devices: Steel 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 nonarmored 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 made of malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A36/A36M 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.

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

3. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F3125/F3125M, Grade A325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.3 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Section 055000 "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with the following standards for application and installation requirements of hangers and supports, except where requirements on Drawings or in this Section are stricter:

1. NECA 1.
2. NECA 101
3. NECA 102.
4. NECA 105.
5. NECA 111.

B. Comply with requirements in Section 078413 "Penetration Firestopping" for firestopping materials and installation for penetrations through fire-rated walls, ceilings, and assemblies.

C. Comply with requirements for raceways and boxes specified in Section 260533 "Raceways and Boxes for Electrical Systems."

D. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

E. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

F. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch 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, according to 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.

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 inchesthick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
6. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
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.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Section 055000 "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 CONCRETE BASES

A. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Section 033000 "Cast-in-Place Concrete."

C. Anchor equipment to concrete base as follows:

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.5 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.

B. Touchup: Comply with requirements in Section 099113 "Exterior Painting"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 A780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS 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. Section Includes:

1. Metal conduits and fittings.
2. Metal wireways and auxiliary gutters.
3. Surface raceways.
4. Boxes, enclosures, and cabinets.

B. Related Requirements:

1. Section 078413 "Penetration Firestopping" for firestopping at conduit and box entrances.

1.3 DEFINITIONS

A. ARC: Aluminum rigid conduit.

B. GRC: Galvanized rigid steel conduit.

C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, and attachment details.

1.5 INFORMATIONAL SUBMITTALS

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

1. Structural members in paths of conduit groups with common supports.
2. HVAC and plumbing items and architectural features in paths of conduit groups with common supports.

B. Qualification Data: For professional engineer.

C. Seismic Qualification Data: Certificates, for enclosures, cabinets, and conduit racks and their mounting provisions, including those for internal components, from manufacturer.

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.
4. Detailed description of conduit support devices and interconnections on which the certification is based and their installation requirements.

D. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS AND FITTINGS

A. Metal Conduit:
1. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit.
    a. Comply with NEMA RN 1.
    b. Coating Thickness: 0.040 inch, minimum.

B. Metal Fittings:
1. Comply with NEMA FB 1 and UL 514B.
2. Listing and Labeling: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Fittings, General: Listed and labeled for type of conduit, location, and use.
4. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 1203 and NFPA 70.
5. Fittings for EMT:
    a. Material: Steel.
    b. Type: compression.
6. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
7. Coating for Fittings for PVC-Coated Conduit: Minimum thickness of 0.040 inch, with overlapping sleeves protecting threaded joints.

C. Joint Compound for IMC, GRC, or ARC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.2 SURFACE RACEWAYS

A. Listing and Labeling: Surface raceways and tele-power poles shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5.

2.3 BOXES, ENCLOSURES, AND CABINETS

A. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.

B. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.

C. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

E. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, galvanized, cast iron with gasketed cover.

F. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

G. Device Box Dimensions: 4 inches square by 2-1/8 inches deep.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed Conduit: PVC coated rigid steal.
2. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
3. Boxes and Enclosures, Aboveground: NEMA 250, Type 4X.

B. Indoors: Apply raceway products as specified below unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed and Subject to Severe Physical Damage: GRC. Raceway locations include the following:
    a. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    b. Mechanical rooms.
3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
5. Damp or Wet Locations: GRC.
6. Boxes and Enclosures: NEMA 250, Type 1

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. 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.
2. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
3. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

E. 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.

F. Do not install aluminum conduits, boxes, or fittings in contact with concrete or earth.

G. Install surface raceways only where indicated on Drawings.

H. 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 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 of enclosures to which attached.

L. Stub-Ups to Above Recessed Ceilings:

1. Use EMT, IMC, or RMC for raceways.

2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

M. 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.

N. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

O. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors including conductors smaller than No. 4 AWG.

P. 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 trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.

Q. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

R. 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.

S. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.

T. 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.

U. Surface Raceways:

1. Install surface raceway with a minimum 2-inch radius control at bend points.
2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding 48 inches and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.

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 RMC 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.

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 36 inches of flexible conduit for 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. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install 0sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Section 078413 "Penetration Firestopping."

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC coatings or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 260533

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.

1.2 SUMMARY

A. Section Includes:

1. Color and legend requirements for raceways, conductors, and warning labels and signs.
2. Labels.
3. Tags

1.3 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.

B. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Comply with ASME A13.1 and IEEE C2.

B. Comply with NFPA 70.

C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.

D. Comply with ANSI Z535.4 for safety signs and labels.

E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

F. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes.

1. Temperature Change: 120 deg F.

2.2 COLOR AND LEGEND REQUIREMENTS

A. Raceways and Cables Carrying Circuits at 600 V or Less:

1. Black letters on an orange field.
2. Legend: Indicate voltage and system or service type.

B. Color-Coding for Phase- and Voltage-Level Identification, 600 V or Less: Use colors listed below for branch-circuit conductors.

1. Color shall be factory applied or field applied for sizes larger than No. 8 AWG if authorities having jurisdiction permit.
2. Colors for 208/120-V Circuits:

    a. Phase A: Black.
    b. Phase B: Red.
    c. Phase C: Blue.

3. Colors for 240-V Circuits:

    a. Phase A: Black.
    b. Phase B: Red.

4. Colors for 480/277-V Circuits:

    a. Phase A: Brown.
    b. Phase B: Orange.
    c. Phase C: Yellow.

5. Color for Neutral: White.
6. Color for Equipment Grounds: Green.
7. Colors for Isolated Grounds: Green with two or more yellow stripes.

C. Equipment Identification Labels:

1. Black letters on a white field.

2.3 LABELS

A. Vinyl Wraparound Labels: Preprinted, flexible labels laminated with a clear, weather- and chemical-resistant coating and matching wraparound clear adhesive tape for securing label ends.

B. Snap-around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeves, with diameters sized to suit diameters and that stay in place by gripping action.

C. Self-Adhesive Wraparound Labels: Preprinted, 3-mil- thick, polyester flexible label with acrylic pressure-sensitive adhesive.
1. Self-Lamination: Clear; UV-, weather- and chemical-resistant; self-laminating, protective shield over the legend. Labels sized such that the clear shield overlaps the entire printed legend.
2. Marker for Labels: Permanent, waterproof, black ink marker recommended by tag manufacturer.

3. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.

D. Self-Adhesive Labels: Polyester, thermal, transfer-printed, 3-mil- thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
1. Minimum Nominal Size:

a. 1-1/2 by 6 inches for raceway and conductors.
b. 3-1/2 by 5 inches for equipment.
c. As required by authorities having jurisdiction.

2.4 TAGS

A. Metal Tags: Brass or aluminum, 2 by 2 by 0.05 inch, with stamped legend, punched for use with self-locking cable tie fastener.

B. Nonmetallic Preprinted Tags: Polyethylene tags, 0.015 inch thick, color-coded for phase and voltage level, with factory printed permanent designations; punched for use with self-locking cable tie fastener.

2.5 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. Paint: Comply with requirements in painting Sections for paint materials and application requirements. Retain paint system applicable for surface material and location (exterior or interior).

B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 PREPARATION

A. Self-Adhesive Identification Products: Before applying electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.

3.2 INSTALLATION

A. Verify and coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, Shop Drawings, manufacturer's wiring diagrams, and operation and maintenance manual. Use consistent designations throughout Project.

B. Verify identity of each item before installing identification products.

C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.

D. Apply identification devices to surfaces that require finish after completing finish work.

E. System Identification for Raceways and Cables under 600 V: Identification shall completely encircle cable or conduit. Place identification of two-color markings in contact, side by side.

1. Secure tight to surface of conductor, cable, or raceway.

F. Accessible Fittings for Raceways: Identify the covers of each junction and pull box of the following systems with the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

G. Self-Adhesive Wraparound Labels: Secure tight to surface at a location with high visibility and accessibility.

H. Self-Adhesive Labels:

1. On each item, install unique designation label that is consistent with wiring diagrams, schedules, and operation and maintenance manual.
2. Unless otherwise indicated, provide a single line of text with 1/2-inch- high letters on 1-1/2-inch- high label; where two lines of text are required, use labels 2 inches high.

I. Snap-around Color-Coding Bands: Secure tight to surface at a location with high visibility and accessibility.

J. Marker Tapes: Secure tight to surface at a location with high visibility and accessibility.

K. Self-Adhesive Vinyl Tape: Secure tight to surface at a location with high visibility and accessibility.

1. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding.

3.3 IDENTIFICATION SCHEDULE

A. Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment. Install access doors or panels to provide view of identifying devices.

B. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, pull points, and locations of high visibility. Identify by system and circuit designation.

C. Accessible Fittings for Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive labels containing the wiring system legend and system voltage. System legends shall be as follows:

1. "EMERGENCY POWER."
2. "POWER."
3. "UPS."

D. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use vinyl wraparound labels to identify the phase.

1. Locate identification at changes in direction, at penetrations of walls and floors, at 50-foot maximum intervals in straight runs, and at 25-foot maximum intervals in congested areas.

E. Equipment Identification Labels:

1. Indoor Equipment: Baked-enamel signs.
2. Outdoor Equipment: Laminated acrylic or melamine sign.
3. Equipment to Be Labeled:
   a. Motor-control centers.
   b. Enclosed switches.
   c. Enclosed circuit breakers.
   d. Enclosed controllers.
   e. Variable-speed controllers.

END OF SECTION 260553

SECTION 262923 - VARIABLE FREQUENCY CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

A. BAS: Building automation system.

B. CE: Conformite Europeene (European Compliance).

C. CPT: Control power transformer.

D. EMI: Electromagnetic interference.

E. IGBT: Insulated-gate bipolar transistor.

F. LAN: Local area network.

G. LED: Light-emitting diode.

H. MCP: Motor-circuit protector.

I. NC: Normally closed.

J. NO: Normally open.

K. OCPD: Overcurrent protective device.

L. PCC: Point of common coupling.

M. PID: Control action, proportional plus integral plus derivative.

N. PWM: Pulse-width modulated.

O. RFI: Radio-frequency interference.

P. TDD: Total demand (harmonic current) distortion.

Q. THD(V): Total harmonic voltage demand.

R. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories. Contractor shall coordinate with equipment vendors and other trades. Comply with control and VFC requirements specified elsewhere in the equipment sections.

B. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
   1. Show tabulations of installed devices, equipment features, and ratings. Include the following:
      a. Each installed unit's type and details.
      b. Factory-installed devices.
      c. Enclosure types and details.
      d. Nameplate legends.
      e. Short-circuit current (withstand) rating of enclosed unit.
      f. Features, characteristics, ratings, and factory settings of each VFC and installed devices.
   2. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.

B. Qualification Data: For qualified testing agency.

C. Product Certificates: For each VFC, from manufacturer.

D. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC to specified levels.

E. Source quality-control reports.

F. Field quality-control reports.

G. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.

H. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01782 "Operation and Maintenance Data," include the following:
1. Manufacturer's written instructions for setting field-adjustable overload relays.
2. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
3. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

1.7 MAINTENANCE MATERIAL SUBMITTALS

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. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Two of each type and color installed.
4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.
1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

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.

D. Installer training to include electrical safety per NFPA 70E and qualified as defined in NEMA PB2.

E. Test an inspect VFD units and associated controls according to requirements in NEMA ICS 61800-2 and UL 508 C. Perform test at rated full load to ensure full operation and provide certified copies of factory test reports. Each drive shall undergo a burn-in test at 100% indicative of motor load prior to final testing.

1.9 DELIVERY, STORAGE, AND HANDLING

A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
   1. Ambient Temperature: Not less than 14 deg F and not exceeding 104 deg F.
   2. Ambient Storage Temperature: Not less than minus 4 deg F and not exceeding 140 deg F
   3. Humidity: Less than 95 percent (noncondensing).
   4. Altitude: Not exceeding 3300 feet.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.11 COORDINATION

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

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.

1.12 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURED UNITS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. ABB
   2. Baldor Electric Company
   3. Eaton Electrical Inc.; Cutler-Hammer Business Unit
   4. Siemens Energy & Automation, Inc
   5. Square D; a brand of Schneider Electric
   6. Toshiba International Corporation
   7. Yaskawa Electric America, Inc; Drives Division

B. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.

C. Application: variable torque.

D. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent

and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.

1. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General-Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.

E. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.

F. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range; maximum voltage equals input voltage.

G. Unit Operating Requirements:
1. Input AC Voltage Tolerance: Plus 10 and minus 10 percent of VFC input voltage rating.
2. Input AC Voltage Unbalance: Not exceeding 3 percent.
3. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
4. Minimum Efficiency: 96 percent at 60 Hz, full load.
5. Minimum Displacement Primary-Side Power Factor: 96 percent under any load or speed condition.
6. Ambient Temperature Rating: Not less than 14 deg F and not exceeding 104 deg F.
7. Ambient Storage Temperature Rating: Not less than minus 4 deg F and not exceeding 140 deg F
8. Humidity Rating: Less than 95 percent (noncondensing).
9. Altitude Rating: Not exceeding 3300 feet.
10. Vibration Withstand: Comply with IEC 60068-2-6.
11. Overload Capability: 1.1 times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
12. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
13. Speed Regulation: Plus or minus 5 percent.
14. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.
15. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.

H. Inverter Logic: Microprocessor based, 16 bit, isolated from all power circuits.

I. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
1. Signal: Electrical.
2. Signal: Pneumatic.

J. Internal Adjustability Capabilities:
1. Minimum Speed: 5 to 25 percent of maximum rpm.
2. Maximum Speed: 80 to 100 percent of maximum rpm.
3. Acceleration: 2 to 22 seconds.
4. Deceleration: 2 to 22 seconds.
5. Current Limit: 30 to minimum of 150 percent of maximum rating.

K. Self-Protection and Reliability Features:
1. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.

2. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
3. Under- and overvoltage trips.
4. Inverter overcurrent trips.
5. VFC and Motor Overload/Over temperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC over temperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
6. Critical frequency rejection, with three selectable, adjustable deadbands.
7. Instantaneous line-to-line and line-to-ground overcurrent trips.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection.
11. Motor over temperature fault.

L. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.

M. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.

N. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.

O. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

P. Integral Input Disconnecting Means and OCPD: NEMA KS 1, fusible switch with pad-lockable, door-mounted handle mechanism.
1. Disconnect Rating: Not less than 115 percent of VFC input current rating.
2. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

2.2 CONTROLS AND INDICATION

A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.

a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.

C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

D. Indicating Devices: Digital displayand additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (V dc).
9. Set point frequency (Hz).
10. Motor output voltage (V ac).

E. Control Signal Interfaces:
1. Electric Input Signal Interface:
   a. A minimum of two programmable analog inputs: 4- to 20-mA dc.
   b. A minimum of six multifunction programmable digital inputs.
   c. If the VFD is not located within site on the motor and a manual disconnect is required to comply with the NEC the contractor shall provide any and all necessary control wiring between the VFD and the contact in the remote disconnect switch.
2. Pneumatic Input Signal Interface: 3 to 15 psig.
3. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
   a. 0- to 10-V dc.
   b. 4- to 20-mA dc.
   c. Potentiometer using up/down digital inputs.
   d. Fixed frequencies using digital inputs.
4. Output Signal Interface: A minimum of one programmable analog output signal(s) (4- to 20-mA dc), which can be configured for any of the following:
   a. Output frequency (Hz).
   b. Output current (load).
   c. DC-link voltage (V dc).
   d. Motor torque (percent).
   e. Motor speed (rpm).
   f. Set point frequency (Hz).
5. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
   a. Motor running.
   b. Set point speed reached.
   c. Fault and warning indication (overtemperature or overcurrent).
   d. PID high- or low-speed limits reached.

F. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
1. Network Communications Ports: Ethernet and RS-485.

2. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet, Echelon LonWorks, Johnson Metasys N2, Modbus/Memobus, Siemens System 600 APOGEE; protocols accessible via the communications ports.

2.3 ENCLOSURES

A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
1. Wet and Outdoor Locations: Type 4X with 316L stainless steel.

2.4 SOURCE QUALITY CONTROL

A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
1. Test each VFC while connected to its specified motor.
2. Verification of Performance: Rate VFCs according to operation of functions and features specified.

B. VFCs will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, NEC working clearances and other conditions affecting performance.

B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.

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

3.2 INSTALLATION

A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

D. Install fuses in each fusible-switch VFC.

E. Install fuses in control circuits if not factory installed. Comply with requirements in Section 16491 "Fuses."

F. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

G. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

H. Comply with NECA 1.

3.3 IDENTIFICATION

A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Electrical Identification."
   1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
   2. Label each VFC with engraved nameplate.
   3. Label each enclosure-mounted control and pilot device.

B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.4 CONTROL WIRING INSTALLATION

A. Install wiring between VFCs and remote devices and facility's central-control system.

B. Bundle, train, and support wiring in enclosures.

C. Connect selector switches and other automatic control devices where applicable.
   1. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
   2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections.
   1. Manufacturer's Field Service: Engage a factory trained and authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Acceptance Testing Preparation:
   1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
   2. Test continuity of each circuit.

C. Tests and Inspections:

1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Construction Manager before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

D. VFCs will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.6 STARTUP SERVICE

A. Engage a factory trained and authorized service representative to perform startup service.
1. Complete installation and startup checks according to manufacturer's written instructions.

3.7 ADJUSTING

A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.

B. Set the taps on reduced-voltage autotransformer controllers.

C. Set field-adjustable circuit-breaker trip ranges as specified in Section 16055 "Overcurrent Protective Device Coordination."

D. Set field-adjustable pressure switches.

3.8 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.

B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.9 DEMONSTRATION

A. Engage a factory trained and authorized service representative to train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 262923