

PROJECT MANUAL

Bolton Center School - Building Automation System Upgrades
108 Notch Rd, Bolton, CT 06043

Issued for Bidding & Construction



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**Bolton CT Center School HVAC Improvement Program
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SECTION 00 0101 - PROJECT TITLE PAGE

1.1 PROJECT MANUAL VOLUME: **Issued for Bidding and Construction**

- A. BAS Upgrades at Bolton Center School
- B. Owner: Bolton Public Schools
- C. Project Location: Bolton, CT
- D. Owner Project No:
- E. Engineer Project No: 2023-3002.01
- F. H. F. Lenz
- G. 101 Centerpoint Dr, Suite 237
- H. Middletown, CT 06457
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- J. Website: www.hflenz.com
- K. Issued: See Request for Proposal for Issuance Date
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END OF SECTION 00 0101

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SECTION 00 0115 - LIST OF DRAWING SHEETS

1.1 LIST OF DRAWINGS

- A. List of Drawings: Drawings consist of the following Contract Drawings and other drawings of type indicated:
 - 1. Cover Sheet
 - 2. Mechanical Drawing consisting of the following:
 - a. M-001: HVAC CONTROL SYSTEM - SCOPE OF WORK

END OF DOCUMENT 00 0115

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SECTION 00 2113 - INSTRUCTIONS TO BIDDERS

1.1 INSTRUCTIONS TO BIDDERS

- A. Request for Proposal, is hereby incorporated into the Procurement and Contracting Requirements by reference.

END OF DOCUMENT 00 2113

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SECTION 00 2600 - PROCUREMENT SUBSTITUTION PROCEDURES

1.1 DEFINITIONS

- A. Procurement Substitution Requests: Requests for changes in products, materials, equipment, and methods of construction from those indicated in the Procurement and Contracting Documents, submitted prior to receipt of bids.
- B. Substitution Requests: Requests for changes in products, materials, equipment, and methods of construction from those indicated in the Contract Documents, submitted following Contract award. See Section 012500 "Substitution Procedures" for conditions under which Substitution requests will be considered following Contract award.

1.2 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.

1.3 PROCUREMENT SUBSTITUTIONS

- A. Procurement Substitutions, General: By submitting a bid, the Bidder represents that its bid is based on materials and equipment described in the Procurement and Contracting Documents, including Addenda. Bidders are encouraged to request approval of qualifying substitute materials and equipment when the Specifications Sections list materials and equipment by product or manufacturer name.
- B. Procurement Substitution Requests will be received and considered by Owner when the following conditions are satisfied, as determined by Engineer; otherwise requests will be returned without action:
 - 1. Extensive revisions to the Contract Documents are not required.
 - 2. Proposed changes are in keeping with the general intent of the Contract Documents, including the level of quality of the Work represented by the requirements therein.
 - 3. The request is fully documented and properly submitted.

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1.4 SUBMITTALS

- A. Procurement Substitution Request: Submit to Engineer. Procurement Substitution Request must be made in writing by prime contract Bidder only in compliance with the following requirements:
1. Requests for substitution of materials and equipment will be considered if received no later than 10 days prior to date of bid opening. See RFP for submission timing requirements.
 2. Submittal Format: Submit Procurement Substitution Request, in writing to District, via process as detailed by District for submission of RFI/Substitutions/Etc. for review.
 - a. Identify the product or the fabrication or installation method to be replaced in each request. Include related Specifications Sections and drawing numbers.
 - b. Provide complete documentation on both the product specified and the proposed substitute, including the following information as appropriate:
 - 1) Point-by-point comparison of specified and proposed substitute product data, fabrication drawings, and installation procedures.
 - 2) Copies of current, independent third-party test data of salient product or system characteristics.
 - 3) Samples where applicable or when requested by Engineer.
 - 4) Detailed comparison of significant qualities of the proposed substitute with those of the Work specified. 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.
 - 5) Material test reports from a qualified testing agency indicating and interpreting test results for compliance with requirements indicated.
 - 6) Research reports, where applicable, evidencing compliance with building code in effect for Project.
 - 7) Coordination information, including a list of changes or modifications needed to other parts of the Work and to construction performed by Owner and separate contractors, which will become necessary to accommodate the proposed substitute.
 - c. Provide certification by manufacturer that the substitute proposed is equal to or superior to that required by the Procurement and Contracting Documents, and that its in-place performance will be equal to or superior to the product or equipment specified in the application indicated.
 - d. Bidder, in submitting the Procurement Substitution Request, waives the right to additional payment or an extension of Contract Time because of the failure of the substitute to perform as represented in the Procurement Substitution Request.

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B. Engineer's Action:

1. Engineer may request additional information or documentation necessary for evaluation of the Procurement Substitution Request. Engineer will notify all bidders of acceptance of the proposed substitute by means of an Addendum to the Procurement and Contracting Documents.

- C. Engineer's approval of a substitute during bidding does not relieve Contractor of the responsibility to submit required shop drawings and to comply with all other requirements of the Contract Documents.

END OF DOCUMENT 00 2600

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SECTION 00 4113 - BID FORM - STIPULATED SUM (SINGLE-PRIME CONTRACT)

1.1 BID INFORMATION

- A. Submit in accordance with Proposal Requirements and Required Formatting as outlined within the Request for Proposal.

1.2 CERTIFICATIONS AND BASE BID

- A. See Request for Proposal for requirements.

1.3 BID GUARANTEE

- A. See Request for Proposal for requirements.

1.4 TIME OF COMPLETION

- A. The Contractor, by submitting their bid, proposes and agrees hereby to commence the Work of the Contract Documents on a date specified in a written Notice to Proceed to be issued by Owner, and shall fully complete the Work prior to the completion date noted within the Request for Proposal.

1.5 ACKNOWLEDGEMENT OF ADDENDA

- A. The undersigned Bidder shall acknowledge receipt of and use of Addenda as required within Request for Proposal.

1.6 CONTRACTOR'S LICENSE

- A. The contractor further states that, by submitting their bid, it is a duly licensed contractor, for the type of work proposed, in Connecticut, and that all fees, permits, etc., pursuant to submitting this proposal shall be paid for by the contractor.

END OF DOCUMENT 00 4113

SECTION 01 1000 - 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. Contractor's use of site and premises.
 - 4. Coordination with occupants.
 - 5. Work restrictions.
 - 6. Specification and Drawing conventions.
 - 7. Miscellaneous provisions.

1.3 DEFINITIONS

- A. Work Package: A group of specifications, drawings, and schedules prepared by the design team to describe a portion of the Project Work for pricing, permitting, and construction.

1.4 WORK COVERED BY CONTRACT DOCUMENTS

- A. The Work of Project is defined by the Contract Documents and includes, but is not limited to, the following:
 - 1. Upgrade of BAS Systems and other Work indicated in the Contract Documents.
- B. Type of Contract:
 - 1. Project will be constructed under a single prime contract.

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1.5 CONTRACTOR'S USE OF SITE AND PREMISES

- A. Limits on 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. Driveways, Walkways and Entrances: Keep driveways, parking garage, loading areas, and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or for storage of materials.
 - a. Schedule deliveries to minimize use of driveways and entrances by construction operations.
 - b. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- B. 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.
- C. Condition of Existing Grounds: Maintain portions of existing grounds, landscaping, and hardscaping affected by construction operations throughout construction period. Repair damage caused by construction operations.

1.6 COORDINATION WITH OCCUPANTS

- A. Full Owner Occupancy: Owner will occupy Project site and existing/adjacent building(s) during entire construction period. Cooperate with Owner during construction operations to minimize conflicts and facilitate Owner usage. Perform the Work so as not to interfere with Owner's day-to-day operations. Maintain existing exits unless otherwise indicated.
 - 1. 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 approval of authorities having jurisdiction.
 - 2. Notify Owner not less than 7 calendar days in advance of activities that will affect Owner's operations.
- B. Owner Limited Occupancy of Completed Areas of Construction: Owner reserves the right to occupy and to place and install equipment in completed portions of the Work, prior to Substantial Completion of the Work, provided such occupancy does not interfere with completion of the Work. Such placement of equipment and limited occupancy shall not constitute acceptance of the total Work.
 - 1. Engineer will prepare a Certificate of Substantial Completion for each specific portion of the Work to be occupied prior to Owner acceptance of the completed Work.

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2. Obtain a Certificate of Occupancy from authorities having jurisdiction before limited Owner occupancy.
3. Before limited Owner occupancy, mechanical and electrical systems shall be fully operational, and required tests and inspections shall be successfully completed. On occupancy, Owner will operate and maintain mechanical and electrical systems serving occupied portions of Work.
4. On occupancy, Owner will assume responsibility for maintenance and custodial service for occupied portions of Work.

1.7 WORK RESTRICTIONS

- A. Comply with restrictions on construction operations.
 1. Comply with limitations on use of public streets, work on public streets, rights of way, and other requirements of authorities having jurisdiction.
- B. On-Site Work Hours, during In-Service School Days: Limit work to between 3 p.m. to 11 p.m., Monday through Friday, unless otherwise indicated. Work hours may be modified to meet Project requirements if approved by Owner and authorities having jurisdiction.
 1. Weekend Hours: To be coordinated with District based on specific date.
 2. Early Morning Hours: To be coordinated with District based on specific date.
 3. Hours for Utility Shutdowns: Two calendar weeks' notice and to be coordinated with District based on specific date.
 4. Hours for Core Drilling: To be coordinated with District based on specific date.
- C. On-Site Work Hours, during No School Days/Summer Vacation: Limit work to between 7 a.m. to 5 p.m., Monday through Friday, unless otherwise indicated. Work hours may be modified to meet Project requirements if approved by Owner and authorities having jurisdiction.
 1. Weekend Hours: To be coordinated with District based on specific date.
 2. Early Morning Hours: To be coordinated with District based on specific date.
 3. Hours for Utility Shutdowns: Two calendar weeks' notice and to be coordinated with District based on specific date.
 4. Hours for Core Drilling: To be coordinated with District based on specific date.
- D. Existing Utility Interruptions: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging for temporary utility services according to requirements indicated:
 1. Notify Engineer/Owner not less than seven days in advance of proposed utility interruptions.
 2. Obtain Engineer's/Owner's written permission before proceeding with utility interruptions.
- E. Noise, Vibration, Dust, and Odors: Coordinate operations that may result in high levels of noise and vibration, dust, odors, or other disruption to Owner occupancy with Owner.

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1. Notify Engineer/Owner not less than seven days in advance of proposed disruptive operations.
 2. Obtain Engineer's/Owner's written permission before proceeding with disruptive operations.
- F. Smoking and Controlled Substance Restrictions: Use of tobacco products, alcoholic beverages, and other controlled substances on Owner's property is not permitted.
- G. Employee Identification: Provide identification tags for Contractor personnel working on Project site. Require personnel to use identification tags at all times.
- H. 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. Text Color: Text used in the Specifications, including units of measure, manufacturer and product names, and other text may appear in multiple colors or underlined as part of a hyperlink; no emphasis is implied by text with these characteristics.
 3. Hypertext: Text used in the Specifications may contain hyperlinks. Hyperlinks may allow for access to linked information that is not residing in the Specifications. Unless otherwise indicated, linked information is not part of the Contract Documents.
 4. Specification requirements are to be performed by Contractor unless specifically stated otherwise.
- B. Division 00 Contracting Requirements: General provisions of the Contract, including General and Supplementary Conditions, apply to all Sections of the Specifications.
- C. Division 01 General Requirements: Requirements of Sections in Division 01 apply to the Work of all Sections in the Specifications.
- D. 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:

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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 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 01 1000

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SECTION 01 2900 - 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 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. Coordinate with RFP and Final Contract. Where RFP/Contract lists specific instances in regards to schedule of values, payment procedures, % contributions to line subject line items, etc. the RFP/Contract shall take precedent over the following specification items.
- B. 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 Engineer at earliest possible date, but no later than seven days before the date scheduled for submittal of initial Applications for Payment.
- C. 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.

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1. Identification: Include the following Project identification on the schedule of values:
 - a. Project name and location.
 - b. Owner's name.
 - c. Owner's Project number.
 - d. Name of Engineer.
 - e. Engineer's Project number.
 - f. Contractor's name and address.
 - g. 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. Overhead Costs, Proportional Distribution: Include total cost and proportionate share of general overhead and profit for each line item.
8. Overhead Costs, Separate Line Items: Show cost of temporary facilities and other major cost items that are not direct cost of actual work-in-place as separate line items.

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9. Temporary Facilities: 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 five percent 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 Engineer paid for by Owner.
- B. Payment Application Times: The date for each progress payment is indicated in the Owner/Contractor Agreement. The period of construction work covered by each Application for Payment is the period indicated in the Agreement.
 1. Submit draft copy of Application for Payment seven days prior to due date for review by Engineer.
- C. Application for Payment Forms: Use AIA Documents, as applicable, as form for Applications for Payment.
- D. Application Preparation: Complete every entry on form. Notarize and execute by a person authorized to sign legal documents on behalf of Contractor. Engineer 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.
- E. 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.

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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.
- F. 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.
- G. Application for Payment at Substantial Completion: After Engineer 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.
 - a. Complete administrative actions, submittals, and Work preceding this application, as described in Section 017700 "Closeout Procedures."

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2. This application shall reflect Certificate(s) of Substantial Completion issued previously for Owner occupancy of designated portions of the Work.
- H. 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. Certification of completion of final punch list items.
 3. Insurance certificates for products and completed operations where required and proof that taxes, fees, and similar obligations were paid.
 4. Updated final statement, accounting for final changes to the Contract Sum.
 5. AIA Document G706.
 6. AIA Document G706A.
 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.
 10. Proof that taxes, fees, and similar obligations are paid.
 11. Waivers and releases.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 2900

SECTION 01 3100 - 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. Related Requirements:
 - 1. Section 013200 "Construction Progress Documentation" for preparing and submitting Contractor's construction schedule.
 - 2. Section 017700 "Closeout Procedures" for coordinating closeout of the Contract.

1.3 DEFINITIONS

- A. RFI: Request for Information. Request from Owner, Engineer, 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.

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- 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, 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 each built facility. Keep list current at all times.

1.5 GENERAL COORDINATION PROCEDURES

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

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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, plumbing, 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 Engineer indicating proposed resolution of such conflicts. Minor dimension changes and difficult installations will not be considered changes to the Contract.
- B. Coordination Drawing Organization: Organize coordination drawings as follows:
1. Floor Plans and Reflected Ceiling Plans: Show architectural and structural elements, and mechanical, plumbing, fire-protection, fire-alarm, and electrical Work. Show locations of visible ceiling-mounted devices relative to acoustical ceiling grid. Supplement plan drawings with section drawings where required to adequately represent the Work.
 2. Mechanical Rooms: Provide coordination drawings for mechanical rooms, showing plans and elevations of mechanical, plumbing, fire-protection, fire-alarm, and electrical equipment.
 3. Structural Penetrations: Indicate penetrations and openings required for all disciplines.
 4. Mechanical and Plumbing Work: Show the following:
 - a. Equipment plans.

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- b. Sizes and bottom elevations of ductwork, piping, and conduit runs, including insulation, bracing, flanges, and support systems.
 - c. Dimensions of major components, such as dampers, valves, diffusers, access doors, cleanouts and electrical distribution equipment.
 - d. Fire-rated enclosures around ductwork.
5. Review: Engineer 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 Engineer determines that coordination drawings are not being prepared in sufficient scope or detail, or are otherwise deficient, Engineer will so inform Contractor, who shall make suitable modifications and resubmit.
6. 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. Engineer will return without response those RFIs submitted to Engineer by other entities controlled by Contractor.
 - 2. Coordinate and submit RFIs in a prompt manner to avoid delays in Contractor's work or work of subcontractors.
- B. Content of the RFI: Include a detailed, legible description of item needing information or interpretation and the following:
- 1. Project name.
 - 2. Owner name.
 - 3. Owner's Project number.
 - 4. Name of Engineer.
 - 5. Engineer's Project number.
 - 6. Date.
 - 7. Name of Contractor.
 - 8. RFI number, numbered sequentially.
 - 9. RFI subject.
 - 10. Specification Section number and title and related paragraphs, as appropriate.
 - 11. Drawing number and detail references, as appropriate.
 - 12. Field dimensions and conditions, as appropriate.
 - 13. Contractor's suggested resolution. If Contractor's suggested resolution impacts the Contract Time or the Contract Sum, Contractor shall state impact in the RFI.
 - 14. Contractor's signature.

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15. Attachments: Include sketches, descriptions, measurements, photos, Product Data, Shop Drawings, coordination drawings, and other information necessary to fully describe items needing interpretation.
 - a. Include dimensions, thicknesses, structural grid references, and details of affected materials, assemblies, and attachments on attached sketches.
- C. RFI Forms: Software-generated form with substantially the same content as indicated above, acceptable to Engineer.
 1. Attachments shall be electronic files in PDF format.
- D. Engineer's Action: Engineer will review each RFI, determine action required, and respond. Allow ten working days for Engineer's response for each RFI. RFIs received by Engineer 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 Engineer's actions on submittals.
 - g. Incomplete RFIs or inaccurately prepared RFIs.
 2. Engineer's action may include a request for additional information, in which case Engineer's time for response will date from time of receipt by Engineer of additional information.
 3. Engineer's action on RFIs that may result in a change to the Contract Time or the Contract Sum may be eligible for Contractor to submit Change Proposal according to Section 012600 "Contract Modification Procedures."
 - a. If Contractor believes the RFI response warrants change in the Contract Time or the Contract Sum, notify Engineer in writing within 5 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 at intervals no less than construction meeting intervals. Use software log that is part of web-based Project management software. Include the following:
 1. Project name.
 2. Name and address of Contractor.
 3. Name and address of Engineer.
 4. RFI number, including RFIs that were returned without action or withdrawn.

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5. RFI description.
 6. Date the RFI was submitted.
 7. Date Engineer's response was received.
 8. Identification of related Minor Change in the Work, Construction Change Directive, and Proposal Request, as appropriate.
- F. On receipt of Engineer's action, update the RFI log and immediately distribute the RFI response to affected parties. Review response and notify Engineer within three days if Contractor disagrees with response.
- G. PDF Document Preparation: Where PDFs are required to be submitted to Engineer, prepare as follows:
1. Assemble complete submittal package into a single indexed file, incorporating submittal requirements of a single Specification Section and transmittal form with links enabling navigation to each item.
 2. Name file with submittal number or other unique identifier, including revision identifier.
 3. Certifications: Where digitally submitted certificates and certifications are required, provide a digital signature with digital certificate on where indicated.

1.8 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 Engineer of scheduled meeting dates and times a minimum of seven 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 Engineer, within three working days of the meeting. Distribution list shall have five working days to make comment of minutes, before minutes become part of project record. Any comments made, shall be picked up on final minutes, within three working days of the end of comment period.
- B. Preconstruction Conference: Schedule and conduct a preconstruction conference before starting construction, at a time convenient to Owner and Engineer, but no later than 15 days after execution of the Agreement.
1. Attendees: Authorized representatives of Owner, Engineer, and their consultants; Contractor and its superintendent; major subcontractors; suppliers; and other concerned parties shall attend the conference. Participants at the conference shall be familiar with Project and authorized to conclude matters relating to the Work.
 2. Agenda: Discuss items of significance that could affect progress, including the following:

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- 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. Preparation of Record Documents.
 - o. Use of the premises and existing building.
 - p. Work restrictions.
 - q. Working hours.
 - r. Owner's occupancy requirements.
 - s. Responsibility for temporary facilities and controls.
 - t. Procedures for moisture and mold control.
 - u. Procedures for disruptions and shutdowns.
 - v. Construction waste management and recycling.
 - w. Parking availability.
 - x. Office, work, and storage areas.
 - y. Equipment deliveries and priorities.
 - z. First aid.
 - aa. Security.
 - bb. Progress cleaning.
 3. Minutes: Entity responsible for conducting meeting will record and distribute meeting minutes.
- C. Progress Meetings: Conduct progress meetings at biweekly intervals, based on construction activities.
1. Coordinate dates of meetings with preparation of payment requests.
 2. Attendees: In addition to representatives of Owner and Engineer, each contractor, subcontractor, supplier, and other entity concerned with current progress or involved in planning, coordination, or performance of future activities shall be represented at these meetings. All participants at the meeting shall be familiar with Project and authorized to conclude matters relating to the Work.
 3. Agenda: Review and correct or approve minutes of previous progress meeting. Review other items of significance that could affect progress. Include topics for discussion as appropriate to status of Project.

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- 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) Status of submittals.
 - 4) Deliveries.
 - 5) Off-site fabrication.
 - 6) Access.
 - 7) Site use.
 - 8) Temporary facilities and controls.
 - 9) Progress cleaning.
 - 10) Quality and work standards.
 - 11) Status of correction of deficient items.
 - 12) Field observations.
 - 13) Status of RFIs.
 - 14) Status of Proposal Requests.
 - 15) Pending changes.
 - 16) Status of Change Orders.
 - 17) Pending claims and disputes.
 - 18) Documentation of information for payment requests.
4. Minutes: Entity responsible for conducting meeting will record significant discussions and agreements achieved. Distribute the meeting minutes to everyone concerned, including Owner and Engineer, within three working days of the meeting. Distribution list shall have five working days to make comment of minutes, before minutes become part of project record. Any comments made, shall be picked up on final minutes, within three working days of the end of comment period.
- 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.

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PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 3100

SECTION 01 3200 - 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.
- B. Related Requirements:
 - 1. Section 014000 "Quality Requirements" for schedule of tests and inspections.
 - 2. Section 012900 "Payment Procedures" for schedule of values and requirements for use of cost-loaded schedule for Applications for Payment.

1.3 DEFINITIONS

- A. Activity: A discrete part of a project that can be identified for planning, scheduling, monitoring, and controlling the construction Project. Activities included in a construction schedule consume time and resources.
 - 1. Critical Activity: An activity on the critical path that must start and finish on the planned early start and finish times.
 - 2. Predecessor Activity: An activity that precedes another activity in the network.
 - 3. Successor Activity: An activity that follows another activity in the network.
- B. Cost Loading: The allocation of the schedule of values for completing an activity as scheduled. The sum of costs for all activities must equal the total Contract Sum.

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- C. Critical Path: The longest connected chain of interdependent activities through the network schedule that establishes the minimum overall Project duration and contains no float.
- D. Event: The starting or ending point of an activity.
- E. Resource Loading: The allocation of manpower and equipment necessary for completing an activity as scheduled.

1.4 INFORMATIONAL SUBMITTALS

- A. Format for Submittals: Submit required submittals in the following format:
 - 1. Working electronic copy of schedule file.
 - 2. PDF file.
- 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.

1.5 QUALITY ASSURANCE

- A. Prescheduling Conference: Conduct conference at Project site to comply with requirements in Section 013100 "Project Management and Coordination." Review methods and procedures related to the preliminary construction schedule and Contractor's Construction Schedule, including, but not limited to, the following:
 - 1. Review software limitations and content and format for reports.

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2. Discuss constraints, including phasing, work stages, area separations, interim milestones, and partial Owner occupancy.
3. Review delivery dates for Owner-furnished products.
4. Review schedule for work of Owner's separate contracts.
5. Review submittal requirements and procedures.
6. Review time required for review of submittals and resubmittals.
7. Review requirements for tests and inspections by independent testing and inspecting agencies.
8. Review time required for Project closeout and Owner startup procedures, including commissioning activities.
9. Review and finalize list of construction activities to be included in schedule.

1.6 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.

1.7 CONTRACTOR'S CONSTRUCTION SCHEDULE

- A. Computer Scheduling Software: Prepare schedules using current version of a program that has been developed specifically to manage construction schedules.
- B. Time Frame: Extend schedule from date established for the Notice of Award 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.
- C. Activities: Treat each floor or separate area as a separate numbered activity for each main element of the Work. Comply with the following:
 1. Temporary Facilities: Indicate start and completion dates for the following as applicable:
 - a. Securing of approvals and permits required for performance of the Work.
 - b. Temporary facilities.
 - c. Construction of mock-ups, prototypes and samples.
 - d. Owner interfaces and furnishing of items.
 - e. Interfaces with Separate Contracts.
 - f. Regulatory agency approvals.

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- g. Punch list.
 - 2. Procurement Activities: Include procurement process activities for the following long lead-time 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.
 - 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 30 days for startup and testing.
 - 5. Commissioning Time: Include no fewer than 30 days for commissioning.
 - 6. Substantial Completion: Indicate completion in advance of date established for Substantial Completion, and allow time for Engineer'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.
- D. 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. 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.
 - 4. 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.
 - 5. 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.
 - 6. 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.

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- 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.
- 7. 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. Completion of mechanical installation.
 - c. Completion of electrical installation.
 - d. Substantial Completion.
- E. 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.
- F. 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.
- G. 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

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working hours, working days, crew sizes, equipment required to achieve compliance, and date by which recovery will be accomplished.

- H. Distribution: Distribute copies of approved schedule to Engineer, 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.

1.8 STARTUP CONSTRUCTION SCHEDULE

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

1.9 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 commencement of the Work.
 - 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.

1.10 REPORTS

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

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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. 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.
- C. 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 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 01 3200

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SECTION 01 3233 - 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. Periodic construction photographs.
 - 2. 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. Digital Photographs: Submit image files within three days of taking photographs.
 - 1. Submit photos by uploading to web-based Project management 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 management software site:
 - a. Name of Project.
 - b. Name and contact information for photographer.
 - c. Name of Engineer.
 - 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.

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1.4 FORMATS AND MEDIA

- A. Digital Images: Submit digital media as originally recorded in the digital camera, without alteration, manipulation, editing, or modifications using image-editing software.
- B. File Names: Name media files with date, project area, and sequential numbering suffix.

1.5 CONSTRUCTION PHOTOGRAPHS

- A. 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.
- B. Final Completion Construction Photographs: Take 50 photographs after date of Substantial Completion for submission as Project Record Documents.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 3233

SECTION 01 3300 - SUBMITTAL PROCEDURES

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

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

B. Related Requirements:

1. Section 012900 "Payment Procedures" for submitting Applications for Payment and the schedule of values.
2. Section 013100 "Project Management and Coordination" for submitting coordination drawings and subcontract list and for requirements for web-based Project software.
3. Section 013200 "Construction Progress Documentation" for submitting schedules and reports, including Contractor's construction schedule.
4. Section 013233 "Photographic Documentation" for submitting preconstruction photographs, periodic construction photographs, and Final Completion construction photographs.
5. Section 014000 "Quality Requirements" for submitting test and inspection reports, and schedule of tests and inspections.
6. Section 017700 "Closeout Procedures" for submitting closeout submittals and maintenance material submittals.
7. Section 017823 "Operation and Maintenance Data" for submitting operation and maintenance manuals.
8. Section 017839 "Project Record Documents" for submitting record Drawings, record Specifications, and record Product Data.
9. Section 017900 "Demonstration and Training" for submitting video recordings of demonstration of equipment and training of Owner's personnel.

1.2 DEFINITIONS

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

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requirements. Informational submittals are those submittals indicated in individual Specification Sections as "informational submittals."

1.3 SUBMITTAL SCHEDULE

- A. Submittal Schedule: Submit, as an action submittal, a list of submittals, arranged in chronological order by dates required by construction schedule. Include time required for review, ordering, manufacturing, fabrication, and delivery when establishing dates. Include additional time required for making corrections or revisions to submittals noted by Engineer and additional time for handling and reviewing submittals required by those corrections.
1. Coordinate submittal schedule with list of subcontracts, the schedule of values, and Contractor's construction schedule.
 2. Initial Submittal Schedule: Submit concurrently with startup construction schedule. Include submittals required during the first 60 days of construction. List those submittals required to maintain orderly progress of the Work and those required early because of long lead time for manufacture or fabrication.
 3. Final Submittal Schedule: Submit concurrently with the first complete submittal of Contractor's construction schedule.
 - a. Submit revised submittal schedule as required to reflect changes in current status and timing for submittals.
 4. Format: Arrange the following information in a tabular format:
 - a. Scheduled date for first submittal.
 - b. Specification Section number and title.
 - c. Submittal Category: Action; informational.
 - d. Name of subcontractor.
 - e. Description of the Work covered.
 - f. Scheduled date for Engineer's final release or approval.

1.4 SUBMITTAL FORMATS

- A. Submittal Information: Include the following information in each submittal:
1. Project name.
 2. Date.
 3. Name of Engineer.
 4. Name of Contractor.
 5. Name of firm or entity that prepared submittal.
 6. Names of subcontractor, manufacturer, and supplier.

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7. Unique submittal number, including revision identifier. Include Specification Section number with sequential alphanumeric identifier and alphanumeric suffix for resubmittals.
8. Category and type of submittal.
9. Submittal purpose and description.
10. Number and title of Specification Section, with paragraph number and generic name for each of multiple items.
11. Drawing number and detail references, as appropriate.
12. Indication of full or partial submittal.
13. Location(s) where product is to be installed, as appropriate.
14. Other necessary identification.
15. Remarks.
16. Signature of transmitter.

- B. Options: Identify options requiring selection by Engineer.
- C. Deviations and Additional Information: On each submittal, clearly indicate deviations from requirements in the Contract Documents, including minor variations and limitations; include relevant additional information and revisions, other than those requested by Engineer on previous submittals. Indicate by highlighting on each submittal or noting on attached separate sheet.
- D. Electronic Submittals: Prepare submittals as PDF package, incorporating complete information into each PDF file. Name PDF file with submittal number.
- E. Submittals Utilizing Web-Based Project Software: Prepare submittals as PDF files or other format indicated by Project management software.

1.5 SUBMITTAL PROCEDURES

- A. Prepare and submit submittals required by individual Specification Sections. Types of submittals are indicated in individual Specification Sections.
 1. Web-Based Project Management Software: Prepare submittals in PDF form, and upload to web-based Project management software website. Enter required data in web-based software site to fully identify submittal.
- B. Coordination: Coordinate preparation and processing of submittals with performance of construction activities.
 1. Coordinate each submittal with fabrication, purchasing, testing, delivery, other submittals, and related activities that require sequential activity.
 2. Submit all submittal items required for each Specification Section concurrently unless partial submittals for portions of the Work are indicated on approved submittal schedule.

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3. Submit action submittals and informational submittals required by the same Specification Section as separate packages under separate transmittals.
 4. Coordinate transmittal of submittals for related parts of the Work specified in different Sections, so processing will not be delayed because of need to review submittals concurrently for coordination.
 - a. Engineer reserves the right to withhold action on a submittal requiring coordination with other submittals until related submittals are received.
 - C. Processing Time: Allow time for submittal review, including time for resubmittals, as follows. Time for review shall commence on Engineer's receipt of submittal. No extension of the Contract Time will be authorized because of failure to transmit submittals enough in advance of the Work to permit processing, including resubmittals.
 1. Initial Review: Allow 15 days for initial review of each submittal. Allow additional time if coordination with subsequent submittals is required. Engineer will advise Contractor when a submittal being processed must be delayed for coordination.
 2. Intermediate Review: If intermediate submittal is necessary, process it in same manner as initial submittal.
 3. Resubmittal Review: Allow 15 days for review of each resubmittal.
 - D. Resubmittals: Make resubmittals in same form and number of copies as initial submittal.
 1. Note date and content of previous submittal.
 2. Note date and content of revision in label or title block, and clearly indicate extent of revision.
 3. Resubmit submittals until they are marked with approval notation from Engineer's action stamp.
 - E. Distribution: Furnish copies of final submittals to manufacturers, subcontractors, suppliers, fabricators, installers, authorities having jurisdiction, and others as necessary for performance of construction activities. Show distribution on transmittal forms.
 - F. Use for Construction: Retain complete copies of submittals on Project site. Use only final action submittals that are marked with approval notation from Engineer's action stamp.
- 1.6 SUBMITTAL REQUIREMENTS
- A. Product Data: Collect information into a single submittal for each element of construction and type of product or equipment.
 1. If information must be specially prepared for submittal because standard published data are unsuitable for use, submit as Shop Drawings, not as Product Data.
 2. Mark each copy of each submittal to show which products and options are applicable.
 3. Include the following information, as applicable:

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- a. Manufacturer's catalog cuts.
 - b. Manufacturer's product specifications.
 - c. Standard color charts.
 - d. Statement of compliance with specified referenced standards.
 - e. Testing by recognized testing agency.
 - f. Application of testing agency labels and seals.
 - g. Notation of coordination requirements.
 - h. Availability and delivery time information.
- 4. For equipment, include the following in addition to the above, as applicable:
 - a. Wiring diagrams that show factory-installed wiring.
 - b. Printed performance curves.
 - c. Operational range diagrams.
 - d. Clearances required to other construction, if not indicated on accompanying Shop Drawings.
- 5. Submit Product Data before Shop Drawings, and before or concurrently with Samples.
- B. Shop Drawings: Prepare Project-specific information, drawn accurately to scale. Do not base Shop Drawings on reproductions of the Contract Documents or standard printed data.
 - 1. Preparation: Fully illustrate requirements in the Contract Documents. Include the following information, as applicable:
 - a. Identification of products.
 - b. Schedules.
 - c. Compliance with specified standards.
 - d. Notation of coordination requirements.
 - e. Notation of dimensions established by field measurement.
 - f. Relationship and attachment to adjoining construction clearly indicated.
 - g. Seal and signature of professional engineer if specified.
- C. Product Schedule: As required in individual Specification Sections, prepare a written summary indicating types of products required for the Work and their intended location. Include the following information in tabular form:
 - 1. Type of product. Include unique identifier for each product indicated in the Contract Documents or assigned by Contractor if none is indicated.
 - 2. Manufacturer and product name, and model number if applicable.
 - 3. Number and name of room or space.
 - 4. Location within room or space.
- D. Qualification Data: Prepare written information that demonstrates capabilities and experience of firm or person. Include lists of completed projects with project names and addresses, contact information of Engineers and owners, and other information specified.

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- E. Design Data: Prepare and submit written and graphic information indicating compliance with indicated performance and design criteria in individual Specification Sections. Include list of assumptions and summary of loads. Include load diagrams if applicable. Provide name and version of software, if any, used for calculations. Number each page of submittal.
- F. Certificates:
1. Certificates and Certifications Submittals: Submit a statement that includes signature of entity responsible for preparing certification. Certificates and certifications shall be signed by an officer or other individual authorized to sign documents on behalf of that entity. Provide a notarized signature where indicated.
 2. Installer Certificates: Submit written statements on manufacturer's letterhead, certifying that Installer complies with requirements in the Contract Documents and, where required, is authorized by manufacturer for this specific Project.
 3. Manufacturer Certificates: Submit written statements on manufacturer's letterhead, certifying that manufacturer complies with requirements in the Contract Documents. Include evidence of manufacturing experience where required.
 4. Material Certificates: Submit written statements on manufacturer's letterhead, certifying that material complies with requirements in the Contract Documents.
 5. Product Certificates: Submit written statements on manufacturer's letterhead, certifying that product complies with requirements in the Contract Documents.
 6. Welding Certificates: Prepare written certification that welding procedures and personnel comply with requirements in the Contract Documents. Submit record of AWS B2.1/B2.1M on AWS forms. Include names of firms and personnel certified.
- G. Test and Research Reports:
1. Compatibility Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of compatibility tests performed before installation of product. Include written recommendations for substrate preparation and primers required.
 2. Field Test Reports: Submit written reports indicating and interpreting results of field tests performed either during installation of product or after product is installed in its final location, for compliance with requirements in the Contract Documents.
 3. Material Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting test results of material for compliance with requirements in the Contract Documents.
 4. Preconstruction Test Reports: Submit reports written by a qualified testing agency, on testing agency's standard form, indicating and interpreting results of tests performed before installation of product, for compliance with performance requirements in the Contract Documents.
 5. Product Test Reports: Submit written reports indicating that current product produced by manufacturer complies with requirements in the Contract Documents. Base reports on evaluation of tests performed by manufacturer and witnessed by a qualified testing agency, or on comprehensive tests performed by a qualified testing agency.

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6. Research Reports: Submit written evidence, from a model code organization acceptable to authorities having jurisdiction, that product complies with building code in effect for Project. Include the following information:
 - a. Name of evaluation organization.
 - b. Date of evaluation.
 - c. Time period when report is in effect.
 - d. Product and manufacturers' names.
 - e. Description of product.
 - f. Test procedures and results.
 - g. Limitations of use.

1.7 CONTRACTOR'S REVIEW

- A. Action Submittals and Informational Submittals: Review each submittal and check for coordination with other Work of the Contract and for compliance with the Contract Documents. Note corrections and field dimensions. Mark with approval stamp before submitting to Engineer.
- B. Contractor's Approval: Indicate Contractor's approval for each submittal with a uniform approval stamp. Include name of reviewer, date of Contractor's approval, and statement certifying that submittal has been reviewed, checked, and approved for compliance with the Contract Documents.
 1. Engineer will not review submittals received from Contractor that do not have Contractor's review and approval.

1.8 ENGINEER'S REVIEW

- A. Action Submittals: Engineer will review each submittal, indicate corrections or revisions required, and return.
 1. Submittals by Web-Based Project Management Software: Engineer will indicate, on Project management software website, the appropriate action.
- B. Informational Submittals: Engineer will review each submittal and will not return it, or will return it if it does not comply with requirements. Engineer will forward each submittal to appropriate party.
- C. Partial submittals prepared for a portion of the Work will be reviewed when use of partial submittals has received prior approval from Engineer.
- D. Incomplete submittals are unacceptable, will be considered nonresponsive, and will be returned for resubmittal without review.

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- E. Engineer will return without review submittals received from sources other than Contractor.
- F. Submittals not required by the Contract Documents will be returned by Engineer without action.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 3300

SECTION 01 4000 - 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 Engineer, Owner, or authorities having jurisdiction are not limited by provisions of this Section.

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 and Inspections: Tests and inspections that are performed on-site for installation of the Work and for completed Work.
- C. Installer/Applicator/Erector: Contractor or another entity engaged by Contractor as an employee, subcontractor, or sub-subcontractor, to perform a particular construction operation, including installation, erection, application, assembly, and similar operations.

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1. Use of trade-specific terminology in referring to a Work result does not require that certain construction activities specified apply exclusively to specific trade(s).
 - D. Preconstruction Testing: Tests and inspections performed specifically for Project before products and materials are incorporated into the Work, to verify performance or compliance with specified criteria. Unless otherwise indicated, copies of reports of tests or inspections performed for other than the Project do not meet this definition.
 - E. Product Tests: Tests and inspections that are performed by a nationally recognized testing laboratory (NRTL) according to 29 CFR 1910.7, by a testing agency accredited according to NIST's National Voluntary Laboratory Accreditation Program (NVLAP), or by a testing agency qualified to conduct product testing and acceptable to authorities having jurisdiction, to establish product performance and compliance with specified requirements.
 - F. Source Quality-Control Tests and Inspections: Tests and inspections that are performed at the source (e.g., plant, mill, factory, or shop).
 - G. Testing Agency: An entity engaged to perform specific tests, inspections, or both. The term "testing laboratory" has the same meaning as the term "testing agency."
 - H. Quality-Assurance Services: Activities, actions, and procedures performed before and during execution of the Work, to guard against defects and deficiencies and substantiate that proposed construction will comply with requirements.
 - I. Quality-Control Services: Tests, inspections, procedures, and related actions during and after execution of the Work, to evaluate that actual products incorporated into the Work and completed construction comply with requirements. Contractor's quality-control services do not include contract administration activities performed by Engineer.
- 1.4 CONFLICTING REQUIREMENTS
- A. Conflicting Standards and Other Requirements: If compliance with two or more standards or requirements is specified and the standards or requirements establish different or conflicting requirements for minimum quantities or quality levels, inform the Engineer regarding the conflict and obtain clarification prior to proceeding with the Work. Refer conflicting requirements that are different, but apparently equal, to Engineer for clarification before proceeding.
 - B. Minimum Quantity or Quality Levels: The quantity or quality level shown or specified is the minimum provided or performed. The actual installation may comply exactly with the minimum quantity or quality specified, or it may exceed the minimum within reasonable limits. To comply with these requirements, indicated numeric values are minimum or maximum, as appropriate, for the context of requirements. Refer uncertainties to Engineer for a decision before proceeding.

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1.5 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. Contractor's Statement of Responsibility: When required by authorities having jurisdiction, submit copy of written statement of responsibility submitted to authorities having jurisdiction before starting work on the following systems:
 - 1. Seismic-force-resisting system, designated seismic system, or component listed in the Statement of Special Inspections.
 - 2. Primary wind-force-resisting system or a wind-resisting component listed in the Statement of Special Inspections.
- D. 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.
- E. 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.
- F. Reports: Prepare and submit certified written reports and documents as specified.
- G. Permits, Licenses, and Certificates: For Owner's record, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents established for compliance with standards and regulations bearing on performance of the Work.

1.6 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 Engineer. Identify personnel, procedures, controls, instructions, tests, records, and forms to be used to carry out Contractor's quality-assurance and quality-control responsibilities and to

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coordinate Owner's quality-assurance and quality-control activities. 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. Special inspections required by authorities having jurisdiction and indicated on the Statement of Special Inspections.
 - 3. Owner-performed tests and inspections indicated in the Contract Documents.
- 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 the 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 Engineer 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.

1.7 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.

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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.

1.8 QUALITY ASSURANCE

- A. Qualifications paragraphs in this article establish the minimum qualification levels required; individual Specification Sections specify additional requirements.
- B. Manufacturer Qualifications: A firm experienced in manufacturing products or systems similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units. As applicable, procure products from manufacturers able to meet qualification requirements, warranty requirements, and technical or factory-authorized service representative requirements.
- C. Fabricator Qualifications: A firm experienced in producing products similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to produce required units.
- D. Installer Qualifications: A firm or individual experienced in installing, erecting, applying, or assembling work similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
- E. Professional Engineer Qualifications: A professional engineer who is legally qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of the system, assembly, or product that is similar in material, design, and extent to those indicated for this Project.
- F. Specialists: Certain Specification Sections require that specific construction activities be performed by entities who are recognized experts in those operations. Specialists will satisfy qualification requirements indicated and engage in the activities indicated.
 1. Requirements of authorities having jurisdiction supersede requirements for specialists.
- G. Testing and Inspecting Agency Qualifications: An NRTL, an NVLAP, or an independent agency with the experience and capability to conduct testing and inspection indicated, as documented in accordance with ASTM E329, and with additional qualifications specified in individual

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Sections; and, where required by authorities having jurisdiction, that is acceptable to authorities.

- H. **Manufacturer's Technical Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to observe and inspect installation of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.
- I. **Factory-Authorized Service Representative Qualifications:** An authorized representative of manufacturer who is trained and approved by manufacturer to inspect, demonstrate, repair, and perform service on installations of manufacturer's products that are similar in material, design, and extent to those indicated for this Project.

1.9 QUALITY CONTROL

- A. **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 will not employ same entity engaged by Owner, unless agreed to in writing by Owner.
 - 3. Notify testing agencies at least 48 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.
- B. **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.
- C. **Testing Agency Responsibilities:** Cooperate with Engineer and Contractor in performance of duties. Provide qualified personnel to perform required tests and inspections.
 - 1. Notify Engineer and Contractor promptly of irregularities or deficiencies observed in the Work during performance of its services.

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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.
- D. 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."
- E. 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.
- F. Contractor's Associated Requirements and Services: Cooperate with agencies and representatives performing required tests, inspections, and similar quality-control services, and provide reasonable auxiliary services as requested. Notify agency sufficiently in advance of operations to permit assignment of personnel. Provide the following:
1. Access to the Work.
 2. Incidental labor and facilities necessary to facilitate tests and inspections.
 3. Adequate quantities of representative samples of materials that require testing and inspection. Assist agency in obtaining samples.
 4. Facilities for storage and field curing of test samples.
 5. 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.
- G. 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.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 TEST AND INSPECTION LOG

- A. Test and Inspection Log: Prepare a record of tests and inspections. Include the following:
 - 1. Date test or inspection was conducted.
 - 2. Description of the Work tested or inspected.
 - 3. Date test or inspection results were transmitted to Engineer.
 - 4. Identification of testing agency or special inspector conducting test or inspection.
- B. Maintain log at Project site. Post changes and revisions as they occur. Provide access to test and inspection log for Engineer's and authorities' having jurisdiction reference during normal working hours.
 - 1. Submit log at Project closeout as part of Project Record Documents.

3.2 REPAIR AND PROTECTION

- A. General: On completion of testing, inspection, sample-taking, and similar services, repair damaged construction and restore substrates and finishes.
 - 1. Provide materials and comply with installation requirements specified in other Specification Sections or matching existing substrates and finishes. Restore patched areas and extend restoration into adjoining areas with durable seams that are as invisible as possible. Comply with the Contract Document requirements for cutting and patching in Section 017300 "Execution."
- B. Protect construction exposed by or for quality-control service activities.
- C. Repair and protection are Contractor's responsibility, regardless of the assignment of responsibility for quality-control services.

END OF SECTION 01 4000

SECTION 01 6000 - 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 011000 "Summary" for Contractor requirements related to Owner-furnished products.
 - 2. Section 012500 "Substitution Procedures" for requests for substitutions.
 - 3. Section 01770 "Closeout Procedures" for submitting warranties.

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. Salvaged items or items reused from other projects are not considered new products. Items that are manufactured or fabricated to include recycled content materials are considered new products, unless indicated otherwise.
 - 3. Comparable Product: Product by named manufacturer that is demonstrated and approved through the comparable product submittal process described in Part 2 "Comparable Products" Article, to have the indicated qualities related to type, function, dimension, in-service performance, physical properties, appearance, and other characteristics that equal or exceed those of specified product.

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- B. **Basis-of-Design Product Specification:** A specification in which a single manufacturer's product is named and accompanied by the words "basis-of-design product," including make or model number or other designation. Published attributes and characteristics of basis-of-design product establish salient characteristics of products.
- C. **Subject to Compliance with Requirements:** Where the phrase "Subject to compliance with requirements" introduces a product selection procedure in an individual Specification Section, provide products qualified under the specified product procedure. In the event that a named product or product by a named manufacturer does not meet the other requirements of the specifications, select another named product or product from another named manufacturer that does meet the requirements of the specifications; submit a comparable product request or substitution request, if applicable.
- D. **Comparable Product Request Submittal:** An action submittal requesting consideration of a comparable product, including the following information:
 - 1. Identification of basis-of-design product or fabrication or installation method to be replaced, including Specification Section number and title and Drawing numbers and titles.
 - 2. Data indicating compliance with the requirements specified in Part 2 "Comparable Products" Article.
- E. **Basis-of-Design Product Specification Submittal:** An action submittal complying with requirements in Section 013300 "Submittal Procedures."
- F. **Substitution:** Refer to Section 012500 "Substitution Procedures" for definition and limitations on substitutions.

1.4 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.
- 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- or power-operated equipment. Locate on a visually accessible but inconspicuous surface. Include information essential for operation, including the following:

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- a. Name of product and manufacturer.
 - b. Model and serial number.
 - c. Capacity.
 - d. Speed.
 - e. Ratings.
3. See individual identification Sections in Divisions 23, 26, and 28 for additional equipment identification requirements.

1.5 COORDINATION

- A. Modify or adjust affected work as necessary to integrate work of approved comparable products and approved substitutions.

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 that products are undamaged and properly protected.
- C. Storage:
 1. Provide a secure location and enclosure at Project site for storage of materials and equipment.
 2. Store products to allow for inspection and measurement of quantity or counting of units.
 3. Store materials in a manner that will not endanger Project structure.
 4. Store products that are subject to damage by the elements under cover in a weathertight enclosure above ground, with ventilation adequate to prevent condensation and with adequate protection from wind.

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5. Protect foam plastic from exposure to sunlight, except to extent necessary for period of installation and concealment.
6. Comply with product manufacturer's written instructions for temperature, humidity, ventilation, and weather-protection requirements for storage.
7. Protect stored products from damage and liquids from freezing.
8. 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 standard warranty form furnished by individual manufacturer for a particular product and issued in the name of the Owner or endorsed by manufacturer to Owner.
 2. Special Warranty: Written warranty required by the Contract Documents to provide specific rights for Owner and issued in the name of the Owner or endorsed by manufacturer to Owner.
- B. Special Warranties: Prepare a written document that contains appropriate terms and identification, ready for execution.
 1. Manufacturer's Standard Form: Modified to include Project-specific information and properly executed.
 2. Specified Form: When specified forms are included in the Project Manual, prepare a written document, using indicated form properly executed.
 3. See other Sections for specific content requirements and particular requirements for submitting special warranties.
- 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.

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2. Standard Products: If available, and unless custom products or nonstandard options are specified, provide standard products of types that have been produced and used successfully in similar situations on other projects.
3. Owner reserves the right to limit selection to products with warranties meeting requirements of the Contract Documents.
4. Where products are accompanied by the term "as selected," Engineer will make selection.
5. Descriptive, performance, and reference standard requirements in the Specifications establish salient characteristics of products.
6. Or Equal: For products specified by name and accompanied by the term "or equal," "or approved equal," or "or approved," comply with requirements in "Comparable Products" Article to obtain approval for use of an unnamed product.
 - a. Submit additional documentation required by Engineer in order to establish equivalency of proposed products. Unless otherwise indicated, evaluation of "or equal" product status is by the Engineer, whose determination is final.

B. Product Selection Procedures:

1. Sole Product: Where Specifications name a single manufacturer and product, provide the named product that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.
 - a. Sole product may be indicated by the phrase "Subject to compliance with requirements, provide the following."
2. Sole Manufacturer/Source: Where Specifications name a single manufacturer or source, provide a product by the named manufacturer or source that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered.
 - a. Sole manufacturer/source may be indicated by the phrase "Subject to compliance with requirements, provide products by the following."
3. Limited List of Products: Where Specifications include a list of names of both manufacturers and products, provide one of the products listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered unless otherwise indicated.
 - a. Limited list of products may be indicated by the phrase "Subject to compliance with requirements, provide one of the following."
4. Non-Limited List of Products: Where Specifications include a list of names of both available manufacturers and products, provide one of the products listed or an unnamed product that complies with requirements.

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- a. Non-limited list of products is indicated by the phrase "Subject to compliance with requirements, available products that may be incorporated in the Work include, but are not limited to, the following."
 - b. Provision of an unnamed product is not considered a substitution, if the product complies with requirements.
- 5. Limited List of Manufacturers: Where Specifications include a list of manufacturers' names, provide a product by one of the manufacturers listed that complies with requirements. Comparable products or substitutions for Contractor's convenience will not be considered unless otherwise indicated.
 - a. Limited list of manufacturers is indicated by the phrase "Subject to compliance with requirements, provide products by one of the following."
- 6. Non-Limited List of Manufacturers: Where Specifications include a list of available manufacturers, provide a product by one of the manufacturers listed or a product by an unnamed manufacturer that complies with requirements.
 - a. Non-limited list of manufacturers is indicated by the phrase "Subject to compliance with requirements, available manufacturers whose products may be incorporated in the Work include, but are not limited to, the following."
 - b. Provision of products of an unnamed manufacturer is not considered a substitution, if the product complies with requirements.
- 7. Basis-of-Design Product: Where Specifications name a product, or refer to a product indicated on Drawings, and include a list of manufacturers, provide the specified or indicated product or a comparable product by one of the other named manufacturers. Drawings and Specifications may additionally indicate sizes, profiles, dimensions, and other characteristics that are based on the product named. Comply with requirements in "Comparable Products" Article for consideration of an unnamed product by one of the other named manufacturers.
 - a. For approval of products by unnamed manufacturers, comply with requirements in Section 012500 "Substitution Procedures" for substitutions for convenience.
- C. Visual Matching Specification: Where Specifications require the phrase "match Engineer's sample," provide a product that complies with requirements and matches Engineer's sample. Engineer's decision will be final on whether a proposed product matches.
 - 1. If no product available within specified category matches and complies with other specified requirements, comply with requirements in Section 012500 "Substitution Procedures" for proposal of product.
- D. Visual Selection Specification: Where Specifications include the phrase "as selected by Engineer from manufacturer's full range" or a similar phrase, select a product that complies

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with requirements. Engineer will select color, gloss, pattern, density, or texture from manufacturer's product line that includes both standard and premium items.

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

2.2 COMPARABLE PRODUCTS

- A. Conditions for Consideration of Comparable Products: Engineer will consider Contractor's request for comparable product when the following conditions are satisfied. If the following conditions are not satisfied, Engineer may return requests without action, except to record noncompliance with the following requirements:
 - 1. Evidence that proposed product does not require revisions to the Contract Documents, is consistent with the Contract Documents, will produce the indicated results, and is compatible with other portions of the Work.
 - 2. Detailed comparison of significant qualities of proposed product with those of the named basis-of-design product. Significant product qualities include attributes, such as type, function, in-service performance and physical properties, weight, dimension, durability, visual characteristics, and other specific features and requirements.
 - 3. Evidence that proposed product provides specified warranty.
 - 4. List of similar installations for completed projects, with project names and addresses and names and addresses of Engineers and owners, if requested.
 - 5. Samples, if requested.
- B. Engineer's Action on Comparable Products Submittal: If necessary, Engineer will request additional information or documentation for evaluation, as specified in Section 013300 "Submittal Procedures."
 - 1. Form of Approval of Submittal: As specified in Section 013300 "Submittal Procedures."
 - 2. Use product specified if Engineer does not issue a decision on use of a comparable product request within time allocated.
- C. Submittal Requirements, Two-Step Process: Approval by the Engineer of Contractor's request for use of comparable product is not intended to satisfy other submittal requirements. Comply with specified submittal requirements.
- D. Submittal Requirements, Single-Step Process: When acceptable to Engineer, incorporate specified submittal requirements of individual Specification Section in combined submittal for comparable products. Approval by the Engineer of Contractor's request for use of comparable product and of individual submittal requirements will also satisfy other submittal requirements.

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PART 3 - EXECUTION (Not Used)

END OF SECTION 01 6000

SECTION 01 7700 - CLOSEOUT PROCEDURES 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.
- B. Related Requirements:
 - 1. Section 012900 "Payment Procedures" for requirements for Applications for Payment for Substantial Completion and Final Completion.
 - 2. Section 013233 "Photographic Documentation" for submitting Final Completion construction photographic documentation.
 - 3. Section 017823 "Operation and Maintenance Data" for additional operation and maintenance manual requirements.
 - 4. Section 017839 "Project Record Documents" for submitting Record Drawings, Record Specifications, and Record Product Data.
 - 5. 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 DEFINITIONS

- A. List of Incomplete Items: Contractor-prepared list of items to be completed or corrected, prepared for the Engineer's use prior to Engineer's inspection, to determine if the Work is substantially complete.

1.4 ACTION SUBMITTALS

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

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

1.5 CLOSEOUT SUBMITTALS

- A. Certificates of Release: From authorities having jurisdiction.
- B. Certificate of Insurance: For continuing coverage.
- C. Field Report: For pest-control inspection.

1.6 MAINTENANCE MATERIAL SUBMITTALS

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

1.7 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 Engineer. 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

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and name and number of related Specification Section. Obtain Engineer's signature for receipt of submittals.

5. Submit testing, adjusting, and balancing records.
 6. 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. Complete startup and testing of systems and equipment.
 2. Perform preventive maintenance on equipment used prior to Substantial Completion.
 3. 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."
 4. Terminate and remove temporary facilities from Project site, along with mockups, construction tools, and similar elements.
 5. Complete final cleaning requirements.
 6. Touch up paint and otherwise repair and restore marred exposed finishes to eliminate visual defects.
- D. Inspection: Submit a written request for inspection to determine Substantial Completion a minimum of 10 days prior to date the Work will be completed and ready for final inspection and tests. On receipt of request, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare the Certificate of Substantial Completion after inspection or will notify Contractor of items, either on Contractor's list or additional items identified by Engineer, that must be completed or corrected before certificate will be issued.
1. 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.

1.8 FINAL COMPLETION PROCEDURES

- A. Submittals Prior to Final Completion: Before requesting final inspection for determining Final Completion, complete the following:
1. Submit a final Application for Payment in accordance with Section 012900 "Payment Procedures."
 2. Certified List of Incomplete Items: Submit certified copy of Engineer's Substantial Completion inspection list of items to be completed or corrected (punch list), endorsed

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and dated by Engineer. Certified copy of the list shall state that each item has been completed or otherwise resolved for acceptance.

3. Certificate of Insurance: Submit evidence of final, continuing insurance coverage complying with insurance requirements.
4. Submit pest-control final inspection report.
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, Engineer will either proceed with inspection or notify Contractor of unfulfilled requirements. Engineer will prepare a final Certificate for Payment after inspection or will notify Contractor of construction that must be completed or corrected before certificate will be issued.

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

1.9 LIST OF INCOMPLETE ITEMS

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

1. Organize list of spaces in sequential order, starting with exterior areas first and proceeding from lowest floor to highest floor, listed by room or space number.
2. Organize items applying to each space by major element, including categories for ceilings, individual walls, floors, equipment, and building systems.
3. Include the following information at the top of each page:
 - a. Project name.
 - b. Date.
 - c. Name of Engineer.
 - d. Name of Contractor.
 - e. Page number.

1.10 SUBMITTAL OF PROJECT WARRANTIES

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

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- B. Partial Occupancy: Submit properly executed warranties within 15 days of completion of designated portions of the Work that are completed and occupied or used by Owner during construction period by separate agreement with Contractor.
- C. Organize warranty documents into an orderly sequence based on the table of contents of Project Manual.
- D. 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.
- 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:

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- a. Clean Project site of rubbish, waste material, litter, and other foreign substances.
 - b. Remove tools, construction equipment, machinery, and surplus material from Project site.
 - c. Remove debris and surface dust from limited-access spaces, including roofs, plenums, shafts, trenches, equipment vaults, manholes, attics, and similar spaces.
 - d. Remove labels that are not permanent.
 - e. Leave Project clean and ready for occupancy.
- C. Construction Waste Disposal: Comply with waste-disposal requirements.

3.2 REPAIR OF THE WORK

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

END OF SECTION 01 7700

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SECTION 01 7823 - 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.

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. Engineer will comment on whether content of operation and maintenance submittals is acceptable.

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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.
- C. Final Manual Submittal: Submit each manual in final form prior to requesting inspection for Substantial Completion and at least 15 days before commencing demonstration and training. Engineer will return copy with comments.
 1. Correct or revise each manual to comply with Engineer's comments. Submit copies of each corrected manual within 15 days of receipt of Engineer's comments and prior to commencing demonstration and training.
- D. 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.

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.

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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 Engineer.
8. Name and contact information for Commissioning Authority.
9. Names and contact information for major consultants to the Engineer 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.

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1.8 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.

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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.

1.9 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.

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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.

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- 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.

1.10 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. 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.

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PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 7823

SECTION 01 7839 - 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 017700 "Closeout Procedures" for general closeout procedures.
 - 2. 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 one set(s) of marked-up record prints.
 - 2. Number of Copies: Submit copies of Record Drawings as follows:
 - a. Initial Submittal:
 - 1) Submit PDF electronic files of scanned record prints and one set(s) of file prints.
 - 2) Engineer 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 file prints.
 - 2) Print each drawing, whether or not changes and additional information were recorded.

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- B. Record Product Data: Submit annotated PDF electronic files and directories of each submittal.
 - 1. Where record Product Data are required as part of operation and maintenance manuals, submit duplicate marked-up Product Data as a component of manual.
- C. 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.
- D. Reports: Submit written report monthly 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. Actual equipment locations.
 - b. Changes made following Engineer's written orders.
 - c. Details not on the original Contract Drawings.
 - d. Field records for variable and concealed conditions.
 - e. Record information on the Work that is shown only schematically.
 - 3. Mark the Contract Drawings and Shop Drawings completely and accurately. Use personnel proficient at recording graphic information in production of marked-up record prints.
 - 4. Mark record prints with erasable, red-colored pencil. Use other colors to distinguish between changes for different categories of the Work at same location.
 - 5. Mark important additional information that was either shown schematically or omitted from original Drawings.

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6. Note Construction Change Directive numbers, alternate numbers, Change Order numbers, and similar identification, where applicable.
- B. 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.
 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 Engineer.
 - e. Name of Contractor.

1.5 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, and Record Drawings where applicable.
- C. Format: Submit Record Product Data as annotated PDF electronic file.
 1. Include Record Product Data directory organized by Specification Section number and title, electronically linked to each item of Record Product Data.

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1.6 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.
 - 1. Include miscellaneous record submittals directory organized by Specification Section number and title, electronically linked to each item of miscellaneous record submittals.

1.7 MAINTENANCE OF RECORD DOCUMENTS

- A. Maintenance of Record Documents: Store Record Documents in the field office apart from the Contract Documents used for construction. Do not use Project Record Documents for construction purposes. Maintain Record Documents in good order and in a clean, dry, legible condition, protected from deterioration and loss. Provide access to Project Record Documents for Engineer's reference during normal working hours.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION (Not Used)

END OF SECTION 01 7839

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SECTION 01 7900 - 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.

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

1.4 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.

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1.5 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 Engineer.

1.6 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.

1.7 INSTRUCTION

- A. Facilitator: Engage a qualified facilitator to prepare instruction program and training modules, to coordinate instructors, and to coordinate between Contractor and Owner for number of participants, instruction times, and location.
- B. Engage qualified instructors to instruct Owner's personnel to adjust, operate, and maintain systems, subsystems, and equipment not part of a system.
- C. Scheduling: Provide instruction at mutually agreed-on times. For equipment that requires seasonal operation, provide similar instruction at start of each season.
 - 1. Schedule training with Owner, through Engineer with at least seven days' advance notice.
- D. Training Location and Reference Material: Conduct training on-site in the completed and fully operational facility using the actual equipment in-place. Conduct training using final operation and maintenance data submittals.
- E. 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.

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PART 2 - PRODUCTS

PART 3 - EXECUTION

END OF SECTION 01 7900

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SECTION 23 0900 - INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SCOPE OF WORK

- A. Provide a new HVAC electric/computer Control System (a.k.a., BMS, BAS, etc.) for the Bolton Center School in Bolton, CT to replace the existing HVAC Control System (HCS).
- B. The priority of this project is to provide the high level, Tier 1, equipment that uses a fully open software system, BACnet/SC. The second priority would be Tier 2 equipment, and the third priority will be connection to individual pieces of equipment.

1.2 RELATED DOCUMENTS

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

1.3 SYSTEM DESCRIPTION

- A. The Direct Digital Control (DDC) System shall be entirely electronic utilizing microprocessor based direct digital controllers and electric valve and damper actuators. System shall be complete as defined in this specification.
- B. The DDC system shall be a peer-to-peer networked, stand-alone, distributed control system that is an 'open system'.
 - 1. An 'open system' shall be defined as one that naturally facilitates and permits the Owner to engage the services of a future vendor different than that which provided this system under this Contract, to service, expand, and modify the system provided without requiring the services of, or future payment to, the controls vendor who initially provided the system.
 - 2. To ensure that an open system is provided, this Direct Digital Control System shall include, but not be limited to having, the following features:
 - a. Utilize only commonplace forms of ANSI/ASHRAE Standard 135 (latest version) BACnet technology communication protocols as further specified herein, and without the use of any proprietary gateways or routers.

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- b. Owner shall request either BACnet software or BACnet/SC software at the time of bidding. The "SC" stands for Secure Connect, a BACnet version that includes secure communication and better integration with building occupant computer systems.
 - c. Utilize only BACnet BTL listed controllers as further specified herein, and are configured in a manner consistent with the listing. Controllers used on the project shall be available through distributor channels so that replacement controllers are not available from a sole source.
 - d. Provide a perpetual and 'unlocked' software license for all software furnished to the Owner.
 - e. Provide native format copies of all software tools, configuration files, control programs, etc. to the Owner.
 - f. Point naming and tagging conventions shall comply with Project Haystack to the greatest extent possible.
- C. User Interface: Complete access* (*all read and write control points, scheduling, and alarm functions established by this project) to the control system, either locally in the building, or remotely, shall be accomplished through the following:
- 1. The herein specified operator's workstation to be located as designated by Owner.
 - a. The graphics and other aspects of the interface may be of the type normally provided by the DDC system supplier.
 - 2. The existing control system workstation and interface software whose location will be provided by the Owner:
 - a. Access to the herein specified new DDC system from the existing control system workstation and head end interface software shall be accomplished without the use of 3rd party or proprietary gateways.
 - b. The navigational and scheduling menus, and alarm management features employed for the herein specified new DDC system at the existing control system head end shall be seamless and of those of the existing interface software in all aspects. Overlays onto the existing system interface of the herein specified DDC system head end graphics that are of the type normally provided by the DDC system supplier are not acceptable.
 - c. DDC system suppliers or sub-contractors providing the herein specified DDC system may employ the services of other controls vendors to meet these requirements, OR may self-perform the work, provided that those technicians providing the integration have at least 1-year experience in programming the current generation of the existing control system. Submit qualifications for the technicians prior to

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performing the work. The DDC system supplier is responsible for correcting any collateral changes to existing programs, menus, or graphics deemed undesirable by the Owner.

- D. The proposed system shall be backwards compatible so as to eliminate system obsolescence.
- E. For functions that mandate it, the new DDC system shall be UL864 UUKL listed for smoke control and life safety or fire alarm use. All controllers, other materials, and programming associated with smoke control system functions shall meet all requirements and recommendations of the 864 UUKL listing.

1.4 SUMMARY

- A. Throughout this specification, any reference to "DDC Contractor or Subcontractor", "ATC Contractor or Subcontractor", "BMS Contractor", "BAS Contractor", "Control Contractor", "installer", "supplier", "Manufacturer" or "local field office" shall be interpreted as referring to the electric/computer control system supplier/installer performing the work of this Section, and Section and 230993 - "Sequence of Operation for HVAC Controls".
- B. All labor, material, equipment and software not specifically referred to herein or on the Drawings, that are required to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- C. The DDC Contractor shall be responsible for integrating factory-supplied HVAC unit controls (supplied by the unit manufacturers) into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.
 - 1. All equipment furnished with controls that are furnished and installed by the manufacturer shall have BACnet MS/TP or BACnet IP communication capability from the equipment manufacturer unless coordinated otherwise between the DDC Contractor and the equipment supplier, with the approval of the Engineer.
 - 2. Coordinate and resolve incompatibility issues that arise between control products provided under this Section and those provided under other Sections or Divisions of the Contract Document Specifications.
 - 3. The DDC Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.
 - 4. Map all available points available from factory supplied control system interfaces.
- D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).

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- E. The system shall be provided completely by the DDC Contractor with the exception of any factory-supplied HVAC unit controls and any factory supplied dampers that are integral to equipment. Furthermore, items such as automatic control valves, separable wells, and field-applied automatic dampers, shall be furnished by the DDC Contractor to the Division 23 Contractor for installation. DDC Contractor shall select the proper location for each control valve, separable well, or damper to be installed by the Division 23 contractor, and shall supervise installation of same.
- F. After completion of the installation, the DDC Contractor shall completely adjust all control equipment provided under this contract, place the system in operation, subject to the engineer's approval, and instruct the operating personnel in the operation of the control system.
- G. The HVAC control system supplier shall satisfactorily complete the entire control system so that it is functional and operating to the satisfaction of the Engineer. Systems and their controls and their sequencing shall be demonstrated and operated to the satisfaction of the Engineer. It is the intent of this specification that this entire system, with its complement of equipment and controls, operate properly in accordance with the design concept and functional intent.
- H. All product names and manufacturer names listed as acceptable products or manufacturers in this Section shall be taken to only be acceptable subject to meeting the project requirements (as defined by the Project Specifications, Sequences of Operation, and Drawings), and approval of a product submittal by the Engineer.

1.5 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements, while all DDC-controlled HVAC systems are operating, and trend data (equivalent to up to 20% of the total system point count, with each trended point collected every 60 seconds) is being reported to the building automation database server:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds, and shall automatically refresh every 15 seconds.
 - 3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
 - 4. Object Command: Reaction time of less than two (2) seconds between operator command of a binary or analog object and device reaction.
 - 5. Object Scan: Transmit change of state and change of analog values to control units or workstation within six (6) seconds.

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6. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations shall receive alarms within five (5) seconds of each other.
7. Program Execution Frequency: Run capability of both custom and standard applications may be as often as five (5) seconds. Select execution times consistent with mechanical process under control.
8. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at an adjustable frequency down to once per second. Select execution times consistent with mechanical process under control.
9. Minimum Reporting Accuracy: Report values within the minimum tolerances as follows, unless a more demanding value is specified elsewhere:
 - a. Water Temperature: ± 0.5 deg F.
 - b. Water Flow: $\pm 3\%$ of full scale.
 - c. Water Pressure, Absolute and Differential: $\pm 2\%$ of full scale.
 - d. Space Temperature: ± 0.5 deg F.
 - e. Ducted Air Temperature: ± 0.5 deg F.
 - f. Outside Air Temperature: ± 1 deg F.
 - g. Dew Point Temperature: ± 3 deg F.
 - h. Temperature Differential: ± 0.25 deg F.
 - i. Relative Humidity: $\pm 6\%$ of full scale.
 - j. Airflow (Pressurized Spaces): $\pm 3\%$ of full scale.
 - k. Airflow (Measuring Stations): $\pm 5\%$ of reading.
 - l. Airflow (Terminal): $\pm 10\%$ of full scale.
 - m. Air Pressure (Space): ± 0.01 -inch w.g.
 - n. Air Pressure (Ducts): ± 0.1 -inch w.g.
 - o. Carbon Monoxide: $\pm 5\%$ of reading.
 - p. Carbon Dioxide: ± 50 ppm.
 - q. Electrical: $\pm 2\%$ of reading.
10. Minimum Control Accuracy: Maintain measured variables within the minimum tolerances as follows, unless a more demanding value is specified elsewhere:

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- a. Water Temperature: ± 1 deg F.
- b. Water Flow: $\pm 5\%$ of full scale.
- c. Water Pressure, Absolute and Differential: $\pm 3\%$ of full scale.
- d. Space Temperature: ± 1.5 deg F.
- e. Ducted Air Temperature: ± 2 deg F.
- f. Relative Humidity: $\pm 6\%$ of full scale.
- g. Airflow (Pressurized Spaces): $\pm 5\%$ of full scale.
- h. Airflow (Measuring Stations): $\pm 7\%$ of reading.
- i. Airflow (Terminal): $\pm 15\%$ of full scale.
- j. Air Pressure (Space): ± 0.02 -inch w.g.
- k. Air Pressure (Ducts): ± 0.2 -inch w.g.
- l. Carbon Dioxide: ± 50 ppm.

1.6 ACTION SUBMITTALS

- A. Qualifications and Proposed System Summary Submittal: The purpose of this submittal is to establish, in a proactive manner, that the vendor proposed by the Division 23 Contractor to perform the work of this Section and related Sections is qualified and intends to deliver the system specified. Failure to obtain approval for this submittal prevents the Contractor from utilizing the proposed vendor. Submittal of detailed information characteristic of the "Primary Submittal" described below without an approved "Qualifications and Proposed System Summary" submittal shall result in rejection of the detailed submittal without review. Within 30 days of contract award or notice to proceed, the Contractor shall submit the following information:

- 1. Qualifications:
 - a. Company name, number of years in business, and any other name the company may have done business under in the last 10 years.
 - b. Location of the nearest full-service office. "Full service" refers to an office staffed with applications engineers, software engineers, and field technicians, that maintains a parts inventory, and that has testing and diagnostic equipment to support the work.
 - c. Resumes of the staff proposed to manage and perform the work of this project.

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- d. Identification of factory-trained technicians directly employed by the proposed vendor, who live within 100 miles of the job site.
 - e. Identification of qualifying project experience, with a description of the work performed, the system installed, and a contact information for the Owner of those projects. Refer to the "Quality Assurance" article below in this Section for additional requirements relating to qualifications, qualifying experience, and number of past projects.
 - 2. Proposed System Summary: Provide the following information for the system proposed to be used for this Project:
 - a. Management level system software platform and details of the user interface software.
 - b. Basic network diagram.
 - c. Product data sheets for Tier 1 (building controllers) and Tier 2 (field level controllers) control equipment. Indicate where and how these controllers can be purchased.
 - d. Communication protocol at each level/ tier of the system.
 - e. Listing of all service tool software required to modify or extend the system, and how usable copies of this software can be obtained by the Owner, and at what cost.
- B. Primary Submittal:
 - 1. Shop drawings and product data of the entire DDC System shall be submitted and shall consist of no less than the following:
 - a. Product Data: A complete list of equipment and materials, including manufacturers catalog data sheets and installation instructions for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics and power requirements, finishes for materials, and installation and startup instructions for each type of product indicated. Include software descriptions, calculations, and any other details required to demonstrate that the system has been coordinated and will properly function as a system.
 - 1) DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.

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- b. Complete wiring and schematic diagrams showing each control point and field device. Schematic control diagrams shall also indicate points obtained from equipment factory packaged control devices. The depictions of these points shall appear alongside field-applied devices and points on the same diagram or schematic.
 - c. Terminal identification for all control wiring. Include all pertinent data, including firmware and software versions, switch settings, and calibration data.
 - d. A complete point list of all points to be connected DDC System.
 - e. List of points obtained through the connection to equipment factory packaged controllers. This list shall appear alongside a points list of field-applied devices and points related to the equipment.
 - f. Proposed point naming and tagging conventions.
 - g. A complete written Sequence of Operation. The sequence shall also incorporate and reflect the control sequence of factory packaged controls.
 - h. Schedule of dampers including size, leakage, and flow characteristics.
 - i. Schedule of valves including flow and pressure drop characteristics, as well as maximum pressure shutoff capability.
 - j. Schedule of damper and valve actuators.
 - k. Schedule of airflow measuring stations. The airflow measuring station manufacturer's representative shall prepare this portion of the submittal by reviewing equipment and ductwork shop drawings to ensure that the proposed installations of the airflow measuring stations meet the requirements and recommendations of the airflow station manufacturers for accuracy, including straight duct upstream and downstream of the station. Install airflow straighteners if required by the manufacturer to meet the specified accuracy given the installation constraints.
 - l. Schedule of hydronic fluid flow measuring stations and/or meters. The flow meter selection, product application, and submittal process and requirements shall be as described above for airflow measuring stations.
- 2. Contractors supplying products and systems as part of their packages shall provide catalog data sheets, wiring diagrams and point lists to the BAS Contractor for proper coordination of work. Such information shall be included in this primary Control submittal.
 - 3. System Architecture Diagrams: Trunk cable schematic diagram depicting Tier 1 (head end) controllers, Tier 2 (field level) controllers, control panel locations and a description

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of the communication type, media and protocol. Though the Division 23 contractors shall provide these diagrams for their portions of work, the BAS Contractor shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Wide Area Network (WAN).

4. Floor Plans: Indicate controller locations and communication trunk cable routing. Indicate sensor locations, except for those installed on or within a piece of equipment, which shall be shown on an equipment control diagram. Indicate control power sources and routing of control power wiring.

C. Graphics Submittal:

1. This submittal shall occur after the primary submittal described above, but not less than 4 weeks prior to the planned date for installing graphics into the system in the field.
2. Include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 90% complete at this stage with the only remaining changes to be based on review comments from the design team and/or Owner.
 - a. The graphics submitted shall be the actual graphics intended to be utilized on this project, and shall be completely job specific.
 - b. Generic or typical graphics are not acceptable, however a single typical graphic may be submitted for types of equipment where this project has multiple, identically controlled pieces of equipment (e.g. VAV boxes, fan coils, etc.).

- D. Samples: For each color required, of each type of thermostat, or space sensor cover.

1.7 INFORMATIONAL SUBMITTALS

- A. Field quality-control or commissioning test reports.
1. Phase I - General Performance Testing reports.
 2. Phase II - Operational Sequence Testing reports.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For HVAC instrumentation and control system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:

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1. Maintenance instructions and lists of spare parts for each type of control device.
 2. Interconnection wiring diagrams with identified and numbered system components and devices.
 3. Keyboard illustrations and step-by-step procedures indexed for each operator function.
 4. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
 5. Calibration records and list of set points.
 6. The point naming and tagging conventions used.
 7. A schedule of all manufacturer's extended warranties on component parts of the DDC system which come with such a warranty. The schedule shall list the start and end dates, the manufacturer's name, and the component or device name. Included with the schedule shall be copies of the manufacturer's warranty certificates.
- B. Software and Firmware Operational Documentation: Include the following:
1. Software operating and upgrade manuals, including the DDC programming tool(s) user manual(s).
 2. Program Software Backup: On a DVD, complete with data files. Files shall include all software, hardware and licenses necessary to operate, maintain, update modify the system. Including a final version of the software operating the building.
 3. Device address list.
 4. Printout of as-built software application and graphic screens. Also include an electronic softcopy.
 5. Software licenses required by and installed for DDC workstations, control systems, and programming tools.
 6. Any additional items described in the article herein titled "Software License Agreement and Service Tools".
- C. Software Upgrade Kit and Upgrade Documentation: For Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
- D. Complete 'As-Built' Documents: Provide electronically and/or in paper form as per the preference of the Owner. Electronic drawings shall be provided as AutoCAD™ compatible files (.dwg or .dxf) or as Visio files, as per the preference of the Owner. Also provide all documents in PDF format. If requested, paper hard copies of the 'as-built' documents shall be provided in addition to the documents on flash drive, DVD, or CD. Contractors shall provide 'as-builts' for their portions of the control work. The Division 23 Controls Sub-contractor shall be responsible

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for 'as-builts' pertaining to overall DDC System Architecture and network diagrams. All as built documents shall also be installed into the DDC System database server in a dedicated directory. Any changes made to graphics or sequences of operation during the Commissioning process shall be included in the as-built documents.

1. Contractor's 'as-built' documents shall include manufacturer's BACnet Protocol Implementation Conformance Statement (PICS) for operator's interface software and every controller model that is installed. Include BTL tested and certified information for the workstation software (device profile B-AWS), and for DDC controllers such as Building Controllers (B-BC), and each standalone DDC control unit (SDCU) conforms to the BACnet device profile B-AAC. Application specific controllers shall conform to BACnet device profile B-ASC.

1.9 WARRANTY

- A. General Warranty: This warranty shall cover all costs for parts, labor, software, associated travel, and expenses for a period of one (1) year from the date of final acceptance by the Engineer and the Owner, and shall keep the control system adjusted throughout the first year.
 1. This warranty shall apply equally to both hardware and software, and all related end devices.
 2. Upon receipt of DDC system commissioning reports (both Phase I and Phase II testing), and when the system performance is deemed satisfactory by the Engineer and the Owner, the system parts will be accepted for beneficial use and the warranty period shall begin.
 3. Provide a quote, at the time of bidding, to extend the general warranty period to a second, full year of warranty and warranty maintenance specified below.
- B. Extended Warranty: The Owner shall be granted no less than five (5) years of software maintenance and updates, at no additional cost. This scope shall include technician labor, and applies to all software furnished, including, but not limited to, software from /for sub-vendors, building controllers, and building automation database servers.

1.10 WARRANTY MAINTENANCE

- A. At no cost to the Owner, during the warranty period, the Contractor shall provide maintenance services for software and hardware components as specified below:
 1. Qualifications: The contractor shall utilize factory-trained technicians located within 100 miles of the job site. Technicians shall be in direct employment of the DDC system sub-contractor.

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2. Maintenance services shall be provided for all devices and hardware specified in this Section. Service all equipment per the manufacturer's recommendations. All devices shall be calibrated within the last month of the warranty period.
3. Emergency Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
 - a. Response to any request for service shall be provided within two (2) hours of the Owner's initial telephone request for service.
 - b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Owner's site within eight (8) hours of the Owner's initial telephone request for such services, as specified.
4. Normal Service: Any malfunction, failure, or defect in any hardware component or failure of any control programming that would not result in property damage or loss of comfort control shall be corrected and repaired following telephonic notification by the Owner to the Contractor.
 - a. Response to any request for service shall be provided within eight (8) working hours (contractor specified 40 hr. per week normal working period) of the Owner's initial telephone request for service.
 - b. In the event that the malfunction, failure, or defect is not corrected through the telephonic communication, at least one (1) hardware and software technician, trained in the system to be serviced, shall be dispatched to the Owner's site within three (3) working days of the Owner's initial telephone request for such services, as specified.
5. Technical Support: Contractor shall provide remote technical support throughout the warrantee period.
6. Preventive maintenance shall be provided throughout the warrantee period in accordance with the hardware component manufacturer's requirements.
7. The Owner shall grant to the DDC System Contractor reasonable access to the DDC System during the warranty period. The Owner shall allow the contractor to access the DDC System from a remote location for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period.

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- B. The Owner shall be granted no less than five (5) years of software maintenance, at no additional cost.

1.11 DEFINITIONS

- A. Some of the acronyms used in this specification are as follows:

BAS	Building Automation System (a.k.a., HVAC Control System)
BMS	Building Management System (a.k.a., HVAC Control System)
DDC	Direct Digital Control System (a.k.a., HVAC Control System)
NAC	Network Area Controller
IBC	Interoperable BACnet Controller
GUI	Graphical User Interface
HCS	HVAC Control System
WBI	Web Browser Interface
POT	Portable Operator's Terminal
PMI	Power Measurement Interface
LAN	Local Area Network
WAN	Wide Area Network
PICS	Product Interoperability Compliance Statement
I/O	Input / Output
MS/TP	Main Subordinate/Token Passing (formerly Master Slave/Token Passing)
PC	Personal Computer
PID	Proportional (plus) Integral (plus) Derivative
RTD	Resistance Temperature Detector
OWS	Operator's WorkStation
AAC	Advanced Application Controller
ASC	Application Specific Controller
HMI	Human-Machine Interface

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Workstation	Generically refers to the HMI and associated software and graphics
HOA	Hand-Off-Auto (switch)
SPST	Single Pole, Single Throw
SPDT	Single Pole, Double Throw
DPDT	Double Pole, Double Throw
DPST	Double Pole, Single Throw
BC	Building Controller
BO	Binary Output*
BI	Binary Input*
AO	Analog Output*
AI	Analog Input*
DO	Digital Output* (= Binary Output)
DI	Digital Input* (= Binary Input)
IP	Internet Protocol
	*(w/ respect to the DDC system)

B. Miscellaneous Definitions:

1. Tier 1: Automation level network (a.k.a. 'head end' or 'host level') generally consisting of the user interface(s), workstation hardware (if present), web server (if present), building and network level controllers, database server, network media converters, routers, and switches.
2. Tier 2: Field level network generally consisting of advanced application controllers, application specific controllers, and controllers that are factory furnished as part of packaged equipment.
3. Throughout this specification, any reference to "DDC Contractor", "HCS Contractor or Subcontractor", "BMS Contractor", "BAS Contractor", "Control Contractor", "installer", "supplier", "Manufacturer" or "local field office" shall be interpreted as referring to the automated control system supplier and installer performing the work of this Section.
4. Where the term 'workstation' is used, it shall mean all means of human-machine interface with the DDC system.

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1.12 SCOPE

A. The scope of work for the HVAC controls system includes, but is not limited to, the following:

1. Provide a complete HVAC Control System for all Division 23 systems and equipment. The HCS shall be fully complete, operable, and ready for the beneficial use of the Owner, unless specifically indicated otherwise by the Owner.
2. Provide raceways and conduits as required by the installation. Provide wiring, cable, conduit, hangers, fittings, and couplings. Make final connections to control devices.
3. Provide water control valves and automatic control air dampers, complete with electric actuators, or as individually specified (see sequence of operations).
4. Provide integration of factory mounted DDC controls furnished under other Sections as described herein.
5. Provide controls in pre-wired apparatus control panels. Internal components shall be fully pre-wired so that only external connections need to be made to these panels. Control panels shall be provided complete with controllers, relays, transformers, terminal strips, wire-way, convenience outlet, and fuses.
6. Furnish complete sets of submittals and installation drawings as described herein.
7. Provide complete start-up, commissioning and testing, and training services.
8. Provide floor plans and mechanical system graphics on the building automation database server.
9. Provide a complete set of DDC operating manuals, programming manuals, maintenance manuals and back up DVD/Software used to set up, and program the DDC system.
10. Provide Owner's Manual, complete operating instructions and spare parts lists.
11. Coordinate DDC work with the work of the other Contractors involved in this project and the Commissioning Agent.
12. Review the approved and finalized HVAC equipment submittals for control requirements of that equipment. Look for requirements related to minimum run times, temperature limits, minimum flow rates, and similar parameters. Modify control programming to implement the equipment manufacturer's recommendations and requirements and/or Engineer's sequences of operation. Direct questions regarding conflicts between manufacturer's requirements and the sequences of operation to the Engineer.
13. Review the Division 23 Contractor's preliminary ductwork and piping shop drawings and identify the required locations of all duct and piping system mounted input and output control devices. Identify conflicts for resolution prior to submission of the shop drawings.

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B. Building Control System Coordination:

1. Factory Controls: The Division 23 Contractor (HVAC system installer) providing HVAC equipment shall coordinate with all of their equipment suppliers providing factory controllers to furnish the following to the DDC Contractor:
 - a. A BACnet Conformance statement applicable to the controller or gateway BACnet device profile classification (i.e. B-OWS Operator Workstation; B-BC Building Controller; B-AAC - Advanced Application Controller; B-ASC - Application Specific Controller; B-SA Smart Actuator; B-SS Smart Sensor, etc.).
 - b. Documentation identifying all addressable points available from the controller or gateway including device ID, detailed point descriptions and addresses.
2. Control Signal and Control Power Wiring: Power wiring HCS system panels and electric actuators will be provided under Division 26 only where such work is shown on the Electrical Drawings. Where such required work is not indicated on the Electrical Drawings, power wiring for control systems shall be provided under Division 23 by the HCS sub-contractor.
 - a. Control signal and interlock wiring (regardless of voltage) for HVAC control systems and equipment shall be provided under Division 23 by the HCS sub-contractor.
 - b. The HCS sub-contractor shall be responsible for furnishing and installing the thermostats, aquastats, etc. and similar line voltage devices for final wiring connections.
 - c. Provide 120V, 20A circuits terminated in junction boxes throughout the building for the HCS system provider sub-contractor's use in providing power to controllers and control devices requiring power, including VAV boxes and similar terminal control equipment. Control power wiring work from these power sources to the cHCS controllers and other devices, including any required control transformers, are the responsibility of the HCS system sub-contractor.
 - d. Provide disconnect (toggle) switches at all 120V power supply connections to control devices. Equipment, and controllers. This includes, but is not limited to, electric actuators, transmitters, and control panels.
 - e. All electrical work provided under Division 23 shall conform to the National Electric Code.
3. Thermowells and Flow Meters: Separable thermowells for pipe mounted temperature sensors required for HCS operation, and flow meters, shall be furnished by the HCS Subcontractor and installed in pipelines by the HVAC system installer at locations required by the HCS Subcontractor.

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4. Pipeline pressure monitoring piping taps shall be provided by the HVAC system installer at locations required by the HCS Subcontractor.
5. Control Valves: Control valves for HVAC equipment shall be furnished by the HCS Subcontractor and installed by the HVAC system installer.
6. Airflow Measuring Stations: Stations, whether duct, plenum, or equipment mounted, shall be furnished by the HCS Subcontractor and installed by the HVAC system installer unless clearly specified to be part of the equipment package. For HCS sub-contractor supplied stations, the HCS subcontractor shall be present at the time the stations are mounted to verify proper installation for accuracy and shall approve the installation.
7. Motor Operated Dampers: Field-applied motor operated dampers shall be furnished by the HCS Subcontractor as per this Section, and installed in ductwork and at intake and discharge air louvers and ventilators under Division 23 by the HVAC systems installer.
 - a. Air handling units and similar equipment may be factory furnished with dampers where indicated in the various other Division 23 equipment specification Sections.
 - b. Unless specified otherwise in the various Division 23 equipment specification Sections, damper operators shall be furnished and installed by the HCS Subcontractor.
 - c. The HCS Subcontractor shall supervise the installation of dampers furnished by them to the Division 23 HVAC systems installer for installation. The HCS Subcontractor shall direct the Division 23 HVAC systems installer to provide blank off plates when the demands of the control application require dampers smaller than duct size in order to provide for sufficiently linearization for control stability.
8. The Division 23 Contractor HVAC System installer shall perform work specified elsewhere in this Section, and the following:
 - a. Provide pressure sensing taps required in piping complete with isolating petcocks.
 - b. Provide various HVAC equipment items complete with self-contained controls as described in other portions of the Specification.
 - c. Provide "review completed" HVAC equipment submittals, including wiring diagrams, to the DDC Contractor for HVAC equipment provided under other Division 23 Sections.
 - d. Verify that the dampers are correctly installed so that they operate freely and close tightly. Provide blank off plates when directly by the HCS Subcontractor to reduce the functional size of control dampers to that which is smaller than the duct size.

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- e. All cutting and patching necessary for the installation, relocation, and demolition of any existing automatic controls system shall be performed by the HVAC systems installer.
- f. Depict the locations, as coordinated with the HCS Subcontractor, of all ductwork and piping system mounted control devices, on the respective ductwork and piping shop drawings, and coordination drawings.

1.13 QUALITY ASSURANCE

- A. System Provider or Sub-Contractor Qualifications: Experienced installers, system integrators, programmers, and controls commissioning technicians who are direct employees of a field office of the specified controls manufacturer or are direct employees of an independent controls contractor that is factory authorized representative of the system proposed.
 - 1. The specific HCS system vendor's office and associated staff being proposed to do the work of this Section shall have:
 - a. Been continuously in business for no less than seven (7) years. Changes in the name of the business due to a change in ownership with no changes in staff other than ownership partners during the seven (7) year period is acceptable.
 - b. A full service office within 100 miles of the project site. "Full service" refers to an office staffed with applications engineers, software engineers, and field technicians, that maintains a parts inventory, and that has testing and diagnostic equipment to support the work.
 - c. Previously completed a minimum of three (3), fully installed, web-based, native BACnet systems similar to the system required for this project. The projects shall have been new system installations (not merely extensions or integrations of existing systems) have been completed within the last four (4) years, but no more recently than 6 months. These projects shall have been installed by the bidding DDC sub-contractors' local office proposed to do the work of this project.
 - d. In their direct employment no less than two (2) technicians who have passed the HVAC Control System training and certification programs shall perform programming and installation of the operator interface for this project. Evidence of these certifications shall be submitted to the Engineer upon request.
 - 1) Programmer Experience: Personnel developing control programs for this project shall be experienced with the control requirements of systems and equipment that are present on this project, have no less than five (5) years' experience in the building automation industry, and have completed no less than five (5) similar projects within the last two (2) years.

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- 2) The HCS Contractor shall utilize different staff for development of different programs for the various equipment and systems included in this project should no single person in their employment have past experience in all equipment and systems included in this project.
 2. The HCS system sub-contractor's project manager for this Project shall have no less than five (5) years of experience as a project manager, and no less than ten (10) years of total experience. All qualifying experience shall be in performing work similar to that described in this Section.
 3. Programmer Experience: Personnel developing control programs for this project shall be experienced with the control requirements of systems and equipment that are present on this project, have no less than five (5) years' experience in the building automation industry, and have completed no less than five (5) similar projects within the last two (2) years. It is required for the BAS Contractor to utilize different staff for development of different programs for the various equipment and systems included in this project should no single person in their employment have past experience in all equipment and systems included in this project.
- B. Control Product Manufacturer Qualifications: A company experienced in manufacturing automatic control systems similar to those indicated for this Project and with a record of successful in-service performance.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. The DDC system and components shall be listed by Underwriters Laboratories (UL 916) as an Energy Management System.
- E. BACnet: The system shall comply with the native BACnet Architecture and web browser access described in this specification. All Tier 1 and 2 controllers shall be approved and BTL listed by BACnet Testing Laboratories.
- F. Code Compliance: All HVAC controls shall be programmed in order to meet all requirements articulated in the current applicable energy conservation code in the project's location.
- G. ASHRAE Guideline 36: Sequences of operation and alarm management methods shall comply with the latest version of the guideline and all current addendums to the greatest extent possible. Identify any discrepancies between the sequences of operation included with these contract documents and the Guideline. Resolve discrepancies by requesting clarification from the Engineer.

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- H. Engineering Review Meeting: After the Engineer has reviewed and returned the first submission of the Primary Submittal, an in-person meeting shall be held between the Engineer and the DDC system provider on a mutually agreeable day and time to review the comments and clarify any project requirements. The DDC system provider shall allocate no less than four (4) hours of meeting time plus travel time and expenses. The meeting will be held at a mutually agreed upon location.
 - 1. It is the responsibility of the DDC system provider to contact the Engineer and propose days and times for the meeting after review of the Engineer's comments on the Primary Submittal.
- I. Point Naming and Tagging Conventions: All point text naming conventions shall be consistent in their use and application throughout the controls system. Point tagging shall be implemented, and shall utilize formats created under Project Haystack where applicable. The DDC system provider may develop their own conventions for tagging points and equipment types not yet covered under Project Haystack, however they shall be as consistent with Project Haystack as possible. Submit proposed point naming and tagging arrangements for approval prior to data entry.

1.14 FACTORY MOUNTED EQUIPMENT CONTROLS

- A. DDC System Provider or Sub-Contractors Scope and Responsibilities:
 - 1. Provide integration of the factory supplied controls into the Building DDC system. Factory supplied control points shall be programmed into the operator's interface, system applications and graphics software and operate seamlessly with the Building DDC system.
 - 2. Coordinate and resolve incompatibility issues that arise between control products provided under this Section and those provided under other Sections or Divisions of the contract document specifications.
 - 3. Communication Gateway Connections: Extend the appropriate or required portion of the DDC system network and connect to all packaged equipment controls, air and water flow meters, and other devices provided with communications gateways.
 - a. DDC system graphics shall initially incorporate all 'communication' points available through integration gateways provided with packaged equipment controls, air and water flow meters, and other devices provided with such communications gateways.
 - b. Within the warranty period, remove any points obtained through the gateway from the workstation graphics that the Owner desires to be removed.

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B. Division 23 Contractor's Scope and Responsibilities:

1. The Division 23 Contractor shall ensure that the equipment manufacturer's representative is on-site during the DDC system commissioning process to ensure full integration of factory controls with the DDC System.
2. The Division 23 Contractor shall ensure that the manufacturer's representatives have made all project-specific adjustments and settings during equipment start-up to the factory controllers prior to the joint field-commissioning efforts.
3. All equipment furnished with controls that are furnished and installed by the manufacturer shall have BACnet MS/TP or BACnet IP communication capability from the equipment manufacturer.
 - a. Modbus TCP/IP is also acceptable, but only if BACnet MS/TP or BACnet IP is not offered by the equipment manufacturer, and the use of Modbus TCP/IP is fully coordinated between the HCS system supplier and the equipment supplier, and is approved by the Engineer and the DDC system sub-contractor.
 - b. The Division 23 Contractor's equipment supplier shall provide to the DDC system sub-contractor all documentation required for the mapping in of points obtained through communication gateway into the DDC system.

- C. Representatives from each manufacturer providing factory mounted controls and the DDC subcontractor shall cooperate in the integration of the individual systems operation prior to bid and during field installation and commissioning or functional testing.

1.15 SOFTWARE LICENSE AGREEMENT

- A. It is the Owners expressed goal to implement an open system that shall allow products from a single supplier to be seamlessly integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.
- B. The DDC sub-contractor or system provider shall provide to the Owner a perpetual software and firmware licensing agreement as a condition of this Contract. When signed by the Owner, it shall grant use of all programs and application software to Owner.
- C. The Owner shall take ownership of all proprietary material generated or used in the execution of this project as a requirement of this Contract.
 1. The Owner shall be the named perpetual license holder of all software associated with any and all incremental work on the project(s), including all configuration and service software tools required for setup and modification of the system, hardware, firmware,

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and documentation that was used in the development, programming, or commissioning of the system for this project.

2. In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, programming tools, and application-level software developed for or used on the project. This shall include all custom, job-specific software code, network management tools, images, record drawings, and documentation for all configuration and programming that is generated for this project and/or configured for use with the DDC system building automation server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices.
 - a. Materials shall be provided in native, virtual formats.
 - b. Copies shall be furnished on the network area controller, database server, and on separate physical media (DVD or flash drive).
 3. The DDC system supplied for this project shall use an open access licensing procedure, and any and all required admin-level IDs and passwords for full access to any component or software program shall be provided to the Owner.
 4. Licenses shall not rely on a physical license key, dongle, or similar device.
 5. Provide no less than three (3) of each type of proprietary hardware required to access the building controllers, if any (e.g. network adapters).
- D. The Owner shall be granted no less than five (5) years of software maintenance, at no additional cost.
- E. Be advised that the Owner will be obtaining the services of a separate control vendor, prior to final payment, to independently verify that all required configuration, programming, and service tools have been provided with the required closeout submittal information and materials turned over the Owner at the conclusion of the project. Verification of an open license will also be performed. All open system requirements specified herein will also be verified.

1.16 SYSTEM SOFTWARE - GENERAL REQUIREMENTS

- A. **Functionality and Completeness:** The Contractor shall furnish and install all software and programming necessary to provide a complete and functioning system as specified. The Contractor shall include all software and programming not specifically itemized in these Specifications that is necessary to implement, maintain, operate, and diagnose the system in compliance with these Specifications.
- B. **Configuration:** The software shall support the system as a distributed processing network configuration.

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- C. Offsite Software Retainage: Contractor shall be required to retain backup copies of custom software drivers and documentation of same for no less than ten (10) years with free access to the Owner for the same period. If the backup is not available within the specified time frame, Contractor shall recreate the custom software at no charge to the Owner.

- D. Site Specific Application Programming: Provide all database creation and site-specific, custom application control programming as required by these specifications, national and local standards, and for a fully functioning system. The BAS Contractor shall provide all initial site-specific application programming and thoroughly document programming. The programming shall meet the functional intent of the sequences of operation included in the contract documents. It is not acceptable for the BAS Contractor to merely provide typical or 'canned' software programs without thorough comparison to the contract document sequences of operation, and resulting modification as required. While the BAS Contractor is encouraged to utilize control programming that has been thoroughly tested and successfully implemented on past projects, where the control applications are very similar to this project, the BAS Contractor is still obligated to make project specific modifications as required, and to identify discrepancies between the Contractor's proposed sequence and those in the contract documents. Similarly, the BAS Contractor shall evaluate the suitability of the contract document sequences of operation for implementation on this project. It is the BAS Contractor's responsibility to request clarification on sequence issues and questions that require such clarification, and to request approval for deviations from the contract document sequences of operation. All site specific programming shall be fully documented and submitted for review and approval, both prior to downloading into the panel, at the completion of functional performance testing, and at the end of the warranty period.

1.17 BIDDING

- A. The DDC system with BACnet programming shall be provided by one of the following controls system suppliers:
 - 1. Automated Logic Corp.
 - 2. Distech Controls.
 - 3. Delta Controls
 - 4. Honeywell - Alerton or Niagara
 - 5. Johnson Controls Inc.
 - 6. Siemens
 - 7. Schneider Electric - Andover
 - 8. Trane

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- B. Subject to compliance with requirements, third party control integrators who are factory licensed or approved installers of control equipment from one of the above listed control manufacturers are also acceptable. .
- C. Bid Compliance, Qualifications, and Proposed System Summary Report:
 - 1. Provide, at the time of bidding a report to determine the DDC Contractor's compliance with the project requirements and these specifications, and to thoroughly understand the system proposed.
 - a. Submit electronically to Owner and Engineer via email as a PDF file. The use of a file transfer site is recommended.
 - b. Failure to submit this compliance report may mean that the DDC sub-contractor's bid is rejected at the Owner's discretion. The compliance report, once submitted, along with all subsequent clarifications provided by the bidder shall constitute an additional exhibit to the construction contract and bid alternate.
 - 2. Qualifications and Proposed System Summary: Include a complete copy of the Qualifications and Proposed System Summary Submittal specified the "Action Submittals" Article above in this Section.
 - 3. Specification Compliance: Include a specification compliance report. This report shall indicate for each article, paragraph, and subparagraph of this Section whether the DDC contractor meets the criteria of the specification. The following format shall be utilized when completing the compliance report:
 - a. Comply - without exception.
 - b. Exception - meet the functional intent. For each paragraph, the contractor shall identify all differences in specific functions stated in the given paragraph and provide a description of what is excluded or how they intend to meet the function specified.
 - c. Does Not Comply - cannot meet they specified function and will not provide.
 - 4. The DDC contractor shall also furnish the following additional information:.
 - a. A complete copy of the Qualifications and Proposed System Summary Submittal specified the "Action Submittals" Article above in this Section.
 - b. Name and qualifications of technicians performing the integration work into the existing HVAC Control System.
 - c. Name of the DDC contractor's intended electrical (installing) sub-contractor, if any.

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- d. Name and resume or qualifications of the intended project manager to be assigned to this project.
 - e. A list of any exceptions taken to the sequences of operation included with the Contract Documents.
 - f. Documentation that illustrates the representative graphics, system navigational features, alarm management, setpoint adjustment, trend displays, programming logic tools, and other important features of the human-machine interface software.
 - g. A minimum of three (3) client references for whom similar or larger projects in size and scope were completed. The projects shall have been completed within the last four (4) years, but no more recently than 6 months.
5. The DDC Contractor may include additional information they choose beyond that listed above; however, this information shall be separated from the above information in a clearly identified, independent Appendix.

D. Pre-Award Demonstration:

- 1. The Owner, Engineer, and Engineer reserve the right to request a DDC system demonstration to gain additional understanding of the system being proposed. The Engineer, Engineer, and Construction Manager may be present to observe and evaluate the demonstration made to the Owner.
- 2. The request, if made, will be made after bids are submitted, but before Contract award. Failure to participate in the demonstration within ten (10) business days of the request shall mean that the DDC sub-contractor's bid may be rejected at the Owner's discretion.
- 3. The following items shall be reviewed during the demonstration:
 - a. Access to the system through a standard web browser.
 - b. Ease-of-use of the system relating to:
 - 1) Changing Schedules.
 - 2) Changing Setpoints.
 - 3) Modifying Program Logic.
 - 4) Modifying Graphics.
 - 5) Reviewing Historical Trends.
 - 6) Downloading Controllers.

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- 7) Review Activity Log.
 - 8) Review/Edit/Acknowledge Alarms.
4. Documentation: The successful bidder shall bring to the demonstration a copy of the documentation that the customer received for each of the projects referenced above. It is the intent of the Owner and Engineer to see how the contractor provides check-out and verification of the control system, along with Owner training.

1.18 GENERAL SYSTEM REQUIREMENTS

- A. Scope: All control functions described in the sequences of operation shall be performed by the DDC system unless explicitly indicated otherwise. All work described shall be provided by the Control system supplier/sub-contractor under this specification Sections unless explicitly indicated otherwise.
1. In addition to meeting the requirements of the specifications, the DDC system sub-contractor is required to provide a particular control point if that control point is indicated in any one of the possible control work representations that are part of these contract drawings. These representations are the entirety of the HVAC drawings, and the control sequences of operation, the points lists, and the control diagrams on the HVAC drawings (when a diagram has been prepared for a given system or type of equipment). The omission of a particular control point from one or more of these representations shall not be construed to mean this particular control point is not required if it is indicated in one of these representations. Inclusion of the point in any one of the representations obligates the Contractor to provide the point as part of the complete and functional control system.
- B. Control Loops:
1. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled.
2. When a control loop is enabled or re-enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a neutral value. The control loop in neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.
3. The term "control loop" or "loop" is used generically for all control loops. These shall typically be PID loops, but proportional plus integral plus derivative gains are not required on all loops. Unless specifically indicated otherwise, the following guidelines shall be followed:

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- a. Use proportional only (P-only) loops for limiting loops (such as zone CO2 control loops, etc.).
 - b. Identify all loop that use a derivative (D) term. Use derivative (D) term on any loops when field tuning is not possible without it.
 4. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.
- C. System Graphics: For each system or each piece of controlled equipment, display all points indicated in the points list, described in the sequences of operation, or indicated in a control diagram on the Drawings, as well as all operating modes, setpoints, high limit settings, time out periods, run times, temperature and pressure reset schedules, and active alarm conditions. Graphics of equipment and systems shall reflect the 'as-built' condition. Locate all instruments and control objects as actually installed in the completed building.
1. Hardwired Points: System graphics shall display all system points associated with physical and hard-wired input and output devices (e.g. temperature and pressure sensors, safety switches, valves, dampers, points to VFDs and magnetic motor starters, etc.)
 2. Gateway Interfaces: System graphics shall incorporate all 'communication' points available through integration gateways provided with packaged equipment controls, air and water flow meters, and other devices provided with such communications gateways. Extend the appropriate or required portion of the DDC system network and connect to all such gateways. All gateway communication points shall be displayed on the system graphics on a separate page, linked from the main system graphic that shows all hard wired points. Communication points selected by the Engineer or the Owner shall also be displayed on the main system graphic.
 3. Additional Specific Requirements:
 - a. Dampers and Valves: Clearly identify the commanded position of each actuator position as % open or % closed. Actuator measured feedback shall be shown on the graphic, included the status of related end switches.
 - b. Air Handling Units and Similar Systems:
 - 1) Display the current outdoor temperature and humidity conditions.
 - 2) Clearly identify and provide navigation links to the graphics of all equipment or systems serving utilities to the air system.
 - 3) Display the current value and current control setpoint of all utilities served to the air system. Use the closest upstream sensor if a local sensor is not in the scope of work.

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- 4) Display the current operating mode of the air system. (e.g. Heating, Cooling, Warm-up, Economizer, etc.)
 - 5) Show all process variables and setpoints related to the discharge of the air system (pressures, flow rates, temperatures, humidity, dewpoint, etc.)
 - 6) Display current CO2 values and control setpoints, as applicable.
- c. VAV Terminal Units:
- 1) Display the current supply air temperature from the air system supplying air to the VAV terminal unit.
 - 2) Clearly identify and provide navigation links to the graphics of the air system serving the VAV terminal unit.
 - 3) Display the current hot water supply temperature being provided by the heating hot water system serving the terminal unit.
 - 4) Display the current operating mode of the VAV terminal unit. (e.g. Heating, Cooling, dead-band, etc.)
 - 5) Display the effective temperature setpoints for the current mode. This value shall reflect any occupant temperature adjustments.
 - 6) Display the zone's occupancy status of the control program.
 - 7) Display current CO2 values and control set points for the space, as applicable.
- D. Adjustable Values: All setpoints, thresholds, differentials, time delays, reset schedules, etc. indicated in the sequences of operation are initial recommendations only and shall be adjustable by the building operator at the DDC workstation or web browser via system graphics without re-programming (i.e. no alteration of system program code shall be required), assuming the user has the required access level.
1. All adjustable values shall be determined and/or verified during the DDC system commissioning process performed by the DDC system sub-contractor.
 2. Software points shall be used for all such adjustable values. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.
- E. VFD Points: Control points for variable frequency drives (VFDs) shall generally be obtained via communications between the VFD and the DDC system, however start/stop commands, speed commands, measured speed, alarm status points, and bypass start/stop and bypass status points, if available, shall be hardwired. Coordinate with the VFD supplier the communications network card required to be furnished with the VFD.

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1. In addition to points indicated in the points list, sequence of operation, or detail on the Drawings, provide the following points through BACnet communications:
 - a. AI - Speed Reference or Feedback
 - b. AI - Drive KW
 - c. Run Time Totalization (hrs.)
 - d. Drive Fault and Warning Details or Messaging
 - e. AI - DC Bus Voltage
- F. Motor Controls:
 1. Wire DDC system contacts for start/stop control over 3-phase motors to the magnetic motor starters.
 2. The DDC system supplier shall provide line voltage control relays for automatic on-off control of single-phase motors. Locate relays near to the associated motor, and coordinate power wiring. The DDC system supplier shall make power and control wiring terminations at the relay.
 3. Electrically Commutated (EC) Motors: EC motors serving fans and pumps indicated in the sequence of operation to have on-off and/or speed control shall receive an external binary and/or analog signal for this purpose. Note that for many EC motors, a zero (0) - VDC or -mA analog speed control signal is used to automatically de-energize the motor. Coordinate signal type requirements with the equipment supplier.
- G. Communication Gateway Connections: Extend the appropriate or required portion of the DDC system network and connect to all packaged equipment controls, air and water flow meters, and other devices provided with communications gateways.
- H. Factory Control Packages: Where equipment is specified in Division 23 with a factory control package, the DDC system sub-contractor shall be responsible for powering the unit controls (if not powered from the equipment's power connection), mapping points into the DDC system workstation when specified with a communication gateway, making control setting adjustments for proper operation with the assistance of the equipment factory's representative, commissioning and functionally testing the factory controls, and installing and wiring any field mounted control devices shipped loose and/or not factory wired.
- I. Units: All temperatures indicated in the sequences are in degrees Fahrenheit (deg. F.). Units of air pressure are in inches water gage (in. w.g.)
- J. Manual Overrides: The DDC system operator shall have the ability to override the speed, position, or operational status of all fans, dampers, pumps, and control valves via override

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command at the operator's workstation, including at the graphics, the I/O points list, and control logic pages. Any points manually commanded by an operator shall be clearly labeled and shall be reflected at all locations where manual commands can be executed. Values on the graphics shall also reflect any operator manual commands.

1. Exceptions: Systems and equipment that perform a safety function shall not be capable of being overridden off or into a mode or position that would reduce the safety of the building. This includes, but is not limited to, lab exhaust fans, grease hood exhaust fans, refrigerant exhaust fans, smoke exhaust fans, stairway or elevator shaft pressurization, fans, and fans dedicated to ventilating fire pump rooms and fire command rooms.
- K. Trends: All inputs, outputs, and calculated points of the DDC system shall be capable of being trended. The DDC system provider shall establish trends for any points the Owner deems necessary. Trends shall be initially set for a sampling rate of once every 5 minutes for each point or as required by the Owner. Trends shall be maintained for a minimum of seven days for all terminal equipment unless required otherwise by the Owner. Viewing of trend graphs shall be available at the DDC workstation or via the web browser. DDC controllers, panels and workstations shall be selected with adequate memory and storage capacity. The workstation shall issue an alarm and provide the user opportunity to save trend data to files prior to erasure of that data. Auto-save features shall be incorporated into the system to retain user-selected trend data without requiring continual user input.
- L. Unless explicitly specified otherwise elsewhere, all modulating dampers and valves shall be proportioning.
- M. Damper and Valve Fail Positions: Unless explicitly specified otherwise elsewhere, all damper and valve actuators shall have spring return mechanisms (except where explicitly noted otherwise, and for 8" valves and larger, which do not require spring return). Unless explicitly indicated otherwise in the sequence of operation or on the Drawings, dampers and valves shall be configured for the following spring return fail positions.
1. Outdoor air damper - Fail closed
 2. Relief air damper - Fail closed
 3. Return air damper - Fail open
 4. Exhaust fan dampers - Fail closed
 5. VAV terminal unit dampers - Fail open
 6. Face and bypass dampers - Fail open to face, closed to bypass
 7. Chilled water coil 2-way control valves - Fail closed
 8. Chilled water coil 3-way control valves - Fail closed to coil flow

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9. Minimum flow bypass valves - Fail closed
 10. Equipment automatic isolation valves - Fail open
 11. Hot water and Steam 2-way control valves for temperature control - Fail Open.
 12. Hot water 3-way control valves for temperature control - Fail open to coil flow.
 13. Water source heat pump source water control valves - Fail open
 14. Note: The normal (e.g. spring return or fail) position of 3-way mixing and diverting valves shall be as described in the sequences of operation or as noted on the Drawings. The graphical representation on details and flow diagrams shall not be construed to indicate otherwise. Mixing and diverting valves shall be piped to produce the normal position described or noted.
- N. Variable air volume terminal units (VAV boxes) shall have separate damper or valve actuators and controllers. Integral or combined controller and actuator devices are not acceptable.
- O. End Switches: End switches, where required by the sequences of operation, shall be a device that verifies the physical position of the damper. The use of auxiliary contacts on the actuator to indicate position is not acceptable. End switches shall be used to provide a "digital (binary) input" (DI) to the DDC system.
1. In addition to those indicated in the Sequences of Operation, provide an end switch to confirm the fully closed status of all dampers at intake and relief /exhaust louvers, gravity ventilators, and similar locations where the damper maintains continuity of the exterior building envelope when the associated air handling apparatus is de-energized or the damper is commanded closed. The DDC system shall issue an alarm when the damper fails to fully close.
- P. Damper and Valve Positions: Knowledge of damper and valve position are required for implementation of trim-and-respond type reset control loops, such as variable speed pump and fan remove differential pressure setpoint reset control. The following are acceptable methods for determining valve and damper positions:
1. Floating Actuators: Provide either a separate position feedback analog input control point, or alternatively, the position may be estimated by timing pulse-open and pulse-closed commands if combined with an auto-zeroing function whenever the damper or valve has been driven full closed. The second option is not acceptable for 24/7 systems or applications that lack an unoccupied mode of operation, unless a forced/override auto-zero is implemented at least once every 48 hours.

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- Q. Temperature Alarms: If space temperatures that are monitored through the DDC system fall more than the adjustable alarm levels, the DDC system shall issue an alarm. Recommended alarm settings:
1. High limit for occupied spaces: 80 deg. F.
 2. High limit for data rooms: 80 deg. F.
 3. High limit for other unoccupied spaces: 90 deg. F.
 4. Low limit for occupied spaces: 62 deg. F.
 5. Low limit for unoccupied spaces: 60 deg. F.
- R. Status Monitoring of Motor Driven Equipment: All fan status monitoring shall be achieved through current switches. All pump status monitoring shall be achieved by differential pressure switches. Both shall have an adjustable trip point. Adjust so that setpoint is below minimum operating current and above motor no-load current.
1. Exception: A pump or direct drive fan status obtained through VFD communications may substitute for a current switch.
 2. Additionally, fans and pumps with flow measuring stations shall have a proof of flow point via the flow station. If current and air or water flow is not detected within 20 seconds of the signal for the fan to start, an alarm shall be issued at the operator's workstation and the fan or pump shall be de-energized.
- S. Space Thermostats: All DDC system space temperature sensors, except for those located in corridors, mechanical and electrical rooms, tele-data rooms, toilet rooms, stairways, entry vestibules, lobbies, and storage rooms shall be provided with a local temperature sensor override feature that permits the user to adjust the space temperature setpoint +/- 2 deg. F. (adjustable) away from the space temperature setpoint set by the DDC system via programming. Sensors shall also incorporate an occupancy override pushbutton that provides a binary input to the DDC system to indicate space occupancy for a 2-hour time period.
- T. Run Time Totalization: The DDC system shall provide a run-time totalization feature for all fans, fan-containing equipment, pumps, boilers, fuel burners (e.g. furnaces boilers, etc.), and refrigerant compressors, and all other HVAC equipment controlled by the DDC system except as noted otherwise.
1. Exception: Run-time totalization is not required for cabinet unit heaters, horizontal unit heaters, and any equipment not being controlled or monitored by the DDC system.
- U. Life Safety Damper Monitoring: The DDC system shall monitor the status of all life safety dampers via the monitoring switch packaged furnished with the damper.

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- V. Space Command Switch or Pushbutton Signage: Provide engraved plastic laminate signage, in letters minimum 1/2-inch high, at all space fan start/stop momentary contact buttons, timing switches, etc. The signage shall indicate the switch/system function. A red plate with white letters shall be used for emergency functions, and white with black letters shall be used for normal or non-emergency functions.
- W. Space-Averaged Temperature Sensors, a.k.a. "Freezestats": Freezestats shall be installed in a uniform, horizontal serpentine pattern and in a downward direction from the body of the device. Element shall be exposed to all areas that encounter low temperature, including along the bottom of the coil(s), from end to end. Provide 1 foot of sensing element for each square foot of coil area. Provide as many freezestats as required for full coverage. Freezestats shall be of the automatic reset type, but a freeze trip only released by way of a manual command at the operator's workstation after three automatic re-start attempts within an 8 hour period.
- X. Safety Device Wiring: Unless explicitly noted otherwise, all safety switches/devices (e.g. freezestats, duct pressure limit switches, etc.) shall be of the automatic reset type but shall provide a digital input (DI) to the DDC system. Smoke detectors shall be manual reset type hardwired to the appropriate motor controller(s) for fan shut down circuit. Manual reset type devices shall also provide a digital input (DI) to the DDC system.
- Y. Stand-By Control Power: HVAC systems and equipment served by a stand by generator shall have associated DDC system products that control such systems and equipment also served from that same stand by generator power source. This shall include building controllers, routers, workstation, and the webserver so that internet access to the system is maintained. All such items shall be powered through a control panel mounted UPS to prevent even a momentary interruption in control and monitoring. See Electrical Drawings for the controls of the equipment that shall be fully operational in the event of a power failure.
- Z. Automatic Restart after Power Failure: Upon restoration of power, the equipment controller shall automatically and without human intervention: update all monitored functions; resume operation based on current, synchronized time and status, and implement special start-up strategies as required.
- AA. Air System Maintenance Start-Stop Switches: A maintenance shutdown or start-up switch shall be provided for each AHU. Locate this switch near to the supply fan VFD. The switch shall provide a pair of binary inputs to the DDC system. Whenever the switch is positioned to 'off', the entire air system shall de-energized via software in the manner identical to the manual system shutdown command initiated through the DDC system interface. The 'on' position or input shall re-start the system in accordance with programming.
 - 1. Provide labeling on the supply and relief fan VFDs and disconnect switches referring staff to the maintenance switches for unit shutdown PRIOR to disconnecting power at service disconnect (safety) switches in order to prevent control system alarms.

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2. Provide labeling on the maintenance switches indicating that these switches are for control system software shutdown of the unit only, and that VFDs or disconnect switches must be locked and tagged prior to working on the unit.
- BB. Mixing Damper Control: Mixing dampers (outdoor air and return air) shall be provided with independent actuators (at least one actuator per damper) and independent analog output control signals from the DDC system controller. Single actuators using physically linked dampers and common control output signals are not acceptable.
1. Linearization Tuning: The DDC system shall be configured to utilize only the linearly-responding portion of the full range stroke of each of the mixing dampers, so as to compensate for the non-linear control characteristic of each installed damper (i.e. due to lack of, or excess amount of, damper authority - as installed in the complete air handling system). By way of signal conversion, the full range of controller output (e.g., the full 0-10VDC range) shall correspond to only the portion (limited range) of the damper actuator stroke which allows the damper to function in a linear manner with respect to airflow rate. Example: Only controlling a parallel blade return damper from 0% to 20% open where that damper that has excessively low control authority (i.e. is quite oversized), in lieu of the damper ranging from 0% to 100% open.
 - a. The DDC system sub-contractor shall observe the response of the installed dampers in the system after start up, and during commissioning of the control system, shall determine the required minimum and maximum settings of each damper individually to produce linear response of the air mixing process.
 - b. If no supply airflow measuring station is present in the system, the Testing, Adjusting, and Balancing Agent shall assist in this process by measuring the mixed airflow (same as supply air) variation of the system, at constant fan speed with all terminal unit positions locked in place, over the full range of mixing damper stroke.
 - c. The linearization tuning process shall be considered acceptable when there is no more than 10% variation in mixed/ supply air flowrate over the entire mixing damper control signal range.
 - d. Damper override signals shall permit dampers to be stroked to any degree of open (anywhere from 0 to 100% or fully open).
 - e. Acceptable compliance approaches include:
 - 1) The DDC system supplier may utilize a Belimo SBG 24 Range Controller to achieve this requirement.
 - 2) A custom linearization function to correct for a known (measured) damper position vs. airflow rate curve.

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- f. The linearization tuning process shall be considered acceptable when it has been observed and documented by flow measurements that there is no more than 10% variation in mixed/ supply air flowrate over the entire mixing damper control signal range.
- CC. Cascade Loops: Cascade loop methods of control over modulating (analog) output devices (e.g. variable speed supply fans, steam and hydronic control valves, etc.) shall be utilized wherever required to produce stable control while providing quick response required to prevent problematic operating conditions or safety shutdowns.
 - 1. Example: Heating coil control valves shall be directly piloted from an averaging temperature sensor located immediately downstream of the coil, with the setpoint of that "local" control loop reset as required to provide the desired unit supply air temperature to the spaces, as measured by a temperature sensor in the main supply air duct connected to the air handling unit. The local HW valve control loop shall be quick reacting, with the reset loop slower reacting. By this method, the heating coil can produce proper temperature air quickly in response to rapid changes in upstream variables to prevent freeze-stat trips or frozen coils, but without the risk of HW valve hunting and other instabilities due to system inertia between the heating coil and the main AHU supply air temperature sensor.
- DD. Duct and Plenum Air Temperature Sensor Applications: Use averaging type temperature sensors in ductwork greater than 48" in any dimension, where air temperature stratification exists (such as a mixed air plenum), immediately downstream of air blenders, and immediately downstream of any heat exchanging element (coil, furnace, etc.).
- EE. Dead-bands: Control loops shall incorporate dead-bands of an appropriate range in order to prevent 'hunting' or excessive 'cycling' of the output device (e.g. variable speed fan controlled to remote duct static pressure, space temperature sensor controlling an on-off exhaust fan, etc.), except as specifically indicated otherwise. Dead-band ranges shall be adjustable, with proposed initial settings indicated on the HCS primary submittal.
- FF. Warm-Up and Cool-Down Modes: Air handling units and similar air systems with time of day schedules (i.e. not continuous operation) shall incorporate warm up and cool down cycles. The units shall be operated in advance of an occupancy period, with a minimum outdoor airflow rate of zero (0) cfm. The duration of this warm up or cool down period shall be auto-adaptive and dependent on the outdoor air temperature and at least one representative space temperature input signal.
- GG. Airflow Measurement of Fan Arrays: The DDC system shall monitor the airflow rate of each individual fan in the array, and shall sum the airflow values from all operating fans to determine the total airflow rate of the array.

PART 2 - PRODUCTS

2.1 CONTROLS SYSTEM ARCHITECTURE

A. General:

1. The Controls System shall consist of a complete peer-to-peer networked, distributed Direct Digital Control System of automatic HVAC control as specified herein and as shown on project Drawings.
2. All system controllers shall be BACnet Testing Laboratories (BTL) listed or certified. Non-listed or non-certified devices are not acceptable. Controllers shall be configured for this project in a manner that is wholly consistent with the BTL listing.
3. The system shall utilize ASHRAE BACnet Standard 135 as the communication protocol (Tier 1) to the workstation and the web browser interface.
 - a. Building level controllers shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
 - b. Building controllers shall support firmware upgrades without the need to replace hardware and shall have a minimum of 10percent spare expansion capacity in total system points and programming functions, and minimum of 10 percent expansion capability in the number of Tier 2 controllers connected.
 - c. The HCS contractor shall supply one or more building controllers as part of this contract. The number and exact model of building controllers required is dependent on the type and quantity of devices required. It is the responsibility of the HCS contractor to configure the Architecture to determine the quantity and type of devices to meet the project requirements and provide the expansion capabilities specified above.
4. The system shall utilize ASHRAE BACnet Standard 135 as the communication protocol (Tier 2) from controller-to-controller. Tier 2 proprietary controllers are not acceptable. Controllers at the Tier 2 level include both advanced application controllers (AACs) and application specific controllers (ASCs).
 - a. All Tier 2 (field level) controllers used on the project shall be available through distributor channels so that replacement controllers are not available from a sole source. Any controllers that are only available through manufacturer's factory offices or factory authorized offices with non-competitive sales territories are not acceptable.

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- b. Advanced application controllers shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
 - 1) Such controllers shall be provided for each major system or piece of equipment, such as air handling units, rooftop units, chilled water system, hot water system, etc., and where application specific controllers cannot meet the project requirements or sequence of operation.
 - 2) Provide point expansion modules where required so that each AAC shall have the following minimum spare point capacities available for future field device connections:
 - a) Analog Inputs: Five (5).
 - b) Analog Outputs: Five (5).
 - c) Binary Inputs: Five (5).
 - d) Binary Outputs: Five (5).
 - e) Universal or configurable points may not be counted twice in order to meet the above requirements.
- c. Application specific controllers (ASCs) shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
 - 1) Such controllers (ASCs) shall only be acceptable for smaller room-level equipment such as radiant panels, fan coil units, unitary heat pumps, fin tube radiators, VAV boxes, cabinet heaters, chilled beams, etc., but only when all required control points are provided and the sequence of operation can be met.
 - 2) Provide point expansion modules where required so that each ASC shall have the following minimum spare point capacities available for future field device connections:
 - a) Analog Inputs: No less than one (1).
 - b) Analog Outputs: No less than one (1).
 - c) Binary Inputs: No less than one (1).
 - d) Binary Outputs: No less than one (1).

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- e) Note: Universal or configurable points may not be counted twice in order to meet the above requirements.
- 5. The building automation database servers and principal network computer equipment shall be standard products of recognized major manufacturers available through normal PC and computer vendor channels - not "Clones" assembled by a third-party subcontractor.
- 6. Provide licenses for all software residing on and used by the Controls Systems and transfer these licenses to the Owner prior to completion.
- 7. The networks shall, at minimum, comprise, as necessary, the following:
 - a. Web Browser Interface
 - b. Network computer processing, data storage and communication equipment including building automation database servers and digital data processors.
 - c. Routers, bridges, switches, hubs, modems, interfaces and the like communication equipment as required for the BAS system network.
 - d. Active processing network controllers including programmable field panels and controllers together with their power supplies and associated equipment.
 - e. Addressable elements, sensors, transducers and end devices.
 - f. Third-party equipment interfaces using BACnet MS/TP or BACnet IP protocol as required by the Contract Documents, either by explicit provision, or by consequence of another explicit Contract provision.
 - g. Other components required for a complete and working Control Systems as specified.

B. Networks:

- 1. The Controls Systems shall incorporate a primary Tier 1 (a.k.a., "host" level or "automation" level) network, and an integrated secondary Tier 2 (a.k.a., "field" level or controller/unitary level) network, as described herein.
- 2. Tier 1 network communications shall be limited to BACnet Ethernet TCP/IP and BACnet IP. Tier 2 network communications shall be BACnet Ethernet TCP/IP, BACnet MS/TP, and BACnet IP. Wireless communications shall be approved by Owner and Engineer prior to

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design or installation. Wireless communications shall be BACnet over Zigbee, and are limited to the Tier 2 network.

- a. The use of ARCNET or ARC156 is not acceptable.
 - b. The use of BACnet PTP or EIA-232 is not acceptable.
 - 1) Exception: When communicating to an existing, separate BACnet network, router to router.
 - c. The use of BACnet over LonTalk, native LonTalk, and Fox are not acceptable.
 - d. The use of any proprietary communication protocol is not acceptable.
3. IP topology at the Tier 2 level shall be 'star' or 'ring' types, or a combination of these two topologies. Daisy chains with a single point of failure are not acceptable.
 4. BACnet IP and TCP/IP communication routers shall comply with BACnet Secure Connect (BACnet/SC) standards using Secure Websockets running over TLS v1.3 security and HTTPS.
 5. The networks shall utilize only copper and optical fiber communication media.
 6. Internet Network Access and Use of the Owner's WAN/LAN:
 - a. The HCS Contractor shall provide access to the Tier 1 LAN from a remote location, via the internet. To enable this access, the Owner will provide a connection to the internet via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). The Owner will agree to pay monthly access charges for the connection and ISP.
 - b. The DDC system networks shall be completely independent from the Owner's WAN/LAN, except for the internet connection described above. The Internet connection shall be to the building automation server. Any additional networking between Tier 1 controllers or from the building automation server and Tier 1 controllers or web server shall be the responsibility of the HCS Contractor.
 - c. The HCS Contractor shall identify the specific Internet and Owner's WAN/LAN access requirements, including location[s], in the primary submittal. The HCS Contractor shall provide the IT interfacing equipment and shall coordinate on configuration and interfacing arrangements with the Owner's IT staff.
 - 1) All DDC system cabling connecting to the Owner's LAN shall be in full compliance with the Owner's IT system requirements and the provisions of Division 27.

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- d. The DDC system Tier 2 network shall be completely independent of the Owner's building WAN/LAN. The networking between ASCs, AACs, and other Tier 2 controllers and the Tier 1 network shall be the responsibility of the HCS Contractor.
 - e. The DDC system communications shall be separated from the rest of the Owner's IT network devices by way of a firewall or VLAN. Coordinate requirements with the Owner's IT staff.
- C. **Wireless Communications:** Wireless communications are acceptable between room temperature sensors and local VAV box controllers and radiant panel controllers where those sensors are shown located on existing masonry walls. If the existing masonry wall is being furred out, or if the wall is new, hard wired communications are required.
 - 1. The wireless communications protocol used shall be BACnet over Zigbee (IEEE 802.15.4).
- D. **Third-Party Interfaces:**
 - 1. DDC Contractor shall integrate real-time data from building systems by other trades and databases originating from other trades as specified and required by the Contract Documents.
 - 2. The Controls Systems shall include necessary hardware, equipment and software to allow data communications between the Controls Systems and building systems supplied by other trades. All other devices shall be definable digital inputs, analog inputs, or BACnet MS/TP or BACnet IP communication capable supplied by the source provided trades.

2.2 OPERATOR'S WORKSTATION

- A. **General:** The application software shall be capable of communication to all Tier 1 and Tier 2 controllers, feature high-resolution color graphics, alarming, reporting, and be user configurable for all data collection and data presentation functions. For multiple user systems, a minimum of 64 workstations shall be allowed on the Ethernet TCP/IP network along with the central file server. In this client/server configuration, any changes or additions made from one workstation shall automatically appear on all other client workstations without the requirement for manual copying of files.
 - 1. **BACnet Compliance:** The workstation software shall conform to the requirements of BACnet device profile B-AWS (advanced operator workstation) as specified in ANSI/ASHRAE 135, BACnet Annex L, and shall be listed as a certified B-AWS in the BACnet Testing Laboratories (BTL) Product Listing.
- B. **Fixed Workstation:** Provide a desktop computer running Microsoft Windows (latest version) operating system to function as an Operator's Workstation (OWS). Locate where shown on the Drawings or where directed by the Owner. The configuration shall be a separate tower and

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monitor (not an "all-in-one" type PC). The workstation provided shall have features required for proper operation, and shall meet the following minimum specifications:

1. 11th Gen. Intel Core i7, 4.0 GHz processor, 8MB cache.
 2. 32 Gb DDR3 RAM memory.
 3. 1 Tb hard drive.
 4. Integrated Video Card Intel GMA3100
 5. Memory Slots: 2 DIMM Slots.
 6. Integrated 8-in-1 Media Card Reader.
 7. Bluetooth: BT 4.0 via 1705 WLAN card.
 8. 27" LCD Monitor.
 9. 48x32 CD-RW/DVD Optical drive.
 10. 10/100 Mbps Integrated Ethernet Port.
 11. USB Optical Mouse.
 12. 104 Key USB Windows Keyboard.
 13. Color ink jet printer.
 14. Available USB or Parallel Port
 15. APC BE500U UPS, 500VA/325 W
 16. Additional Software: Microsoft Office 365.
- C. The software shall be capable of communication to all Level 1 and Level 2 controllers, feature high-resolution color graphics, alarming, event recording, reporting, scheduling, and be user configurable for all data collection and data presentation functions.
- D. Communications to Level 1 controllers shall be via Ethernet TCP/IP and/or fiber optic LAN connection.

2.3 OPERATOR INTERFACE AND MANAGEMENT LEVEL SOFTWARE - BASIC REQUIREMENTS

- A. Acceptable Platforms: Provide Submittal from proposed HCS equipment manufacturer for review by Owner and Engineer prior to purchase or installation. Submittal shall be equivalent in capabilities, "BACnet openness," security, and ease of use to the following:
1. Tridium 'Niagara 4' or 'Vykon'

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2. Distech Controls - 'EC-Net'
 3. Lynxspring - 'JENEsys'
- B. The Controls Systems Operator Interface Software shall be user friendly, readily understood and shall make maximum use of colors, graphics, icons, embedded images, animation, text based information and data visualization techniques to enhance and simplify the use and understanding of the displays by authorized users at the Operator's Workstation.
- C. User access shall be protected by a flexible and Owner re-definable software-based password access protection. Password protection shall be multi-level and partitionable to accommodate the varied access requirements of the different user groups to which individual users may be assigned. Provide the means to define unique access privileges for each individual authorized user. Provide the means to on-line manage password access control under the control of a project specific Master Password. Provide an audit trail of all user activity on the Controls Systems including all actions and changes.
- D. The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:
1. User access for selective information retrieval and control command execution.
 2. Monitoring and reporting.
 3. Alarm and non-normal condition annunciation.
 4. Selective operator override and other control actions.
 5. Information archiving, manipulation, formatting, display and reporting.
 6. Controls Systems internal performance supervision and diagnostics.
 7. On-line access to user HELP menus and files.
 8. On-line access to current 'as-built' records and documents. At minimum, one (1) copy of all 'as-built' documentation shall be stored on a designated Operator's Workstation or Server and be accessible to the Owner.
 9. Means for the controlled re-programming, re-configuration of systems operation and for the manipulation of database information in compliance with the prevailing codes, approvals and regulations for the component applications and elements.
 10. Means to archive all Controls Systems Contract Project specific configuration databases, software programs and other pertinent operational data such that any component of the software and project specific operational databases may be reloaded on-site from archived data.

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- E. Provide on-line reports and displays making maximized use of simple English language descriptions and readily understood acronyms, abbreviations, icons and the like to assist user understanding and interpretation.
- F. All devices, including OWS, servers and controllers, required to support and drive the Operator Interfaces shall support multiple independent user terminals through a theoretical unlimited number of Browsers. Support shall be configured for minimum of (25) users/clients for all applications and features provided.
- G. Controls Applications:
 - 1. Provide a color graphic system flow diagram display for each HVAC system with all points as indicated in the sequences of operation and on the point list. Provide Historical Data Viewer functionality.
 - 2. Provide a text sequence of operation for each system launched from the graphic.
 - 3. Provide a color graphic display for each floor in the facility. Indicate each HVAC zone, color coded to indicate zone values and status.
 - 4. Provide DDC System configuration diagrams and bill-of-material for all provided equipment on-line and able to be launched from the OWS.
- H. Refer to the Article in this Section titled "Controls Systems Application - Specifics" for additional requirements.

2.4 WEB SERVER OR WEB BROWSER INTERFACE

- A. The web browser interface (WBI) shall provide an additional means of operator workstation (OWS) interface and communication with the Controls Systems and shall be used for controlling, monitoring, operations, engineering, management, archiving, audit, reporting and other related functions. It shall provide secure web access from any computer on the Owner's LAN or with internet access.
- B. All aspects of the Controls Systems Operator Interface shall be provided to operate through an IT industry standard Web Browsers such as Microsoft Edge™, Google Chrome™, Mozilla Firefox™, Apple Safari™, or approved equivalent on any Web enabled device including tablet computers and smartphones.
- C. The Web Browser based Operator Interface shall support automatic scaling of graphic screens to any sized display device, i.e. desktop computer; laptop computer; tablet; or smart phone.

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- D. The Web Browser based Operator Interface provided shall incorporate complete tool sets, operational information displays, multi-Window displays and other interactive aids to assist interpretation and ease of use. Simple HTML based web page displays are not acceptable.
- E. The Web Browser based Operator Interface provided shall not require the procurement or licensing of any special or proprietary software from the DDC Contractor or its suppliers for the Controls Systems OWS. The system shall be capable of supporting at least (25) clients using a standard Web browser, such as those listed above. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
- F. Security: The system shall provide for secure remote access. Access shall not require additional software to be installed on the client device (VPN).
 - 1. User log-on identification and password shall be required, and the implementation of two-factor authentication process shall be available. If an unauthorized user attempts access, a blank web page shall be displayed.
 - 2. The server application shall support transfer layer security (TLS) with Java AES-256 (256 bit key length) encryption and authentication techniques to prevent unauthorized access. The server application shall also have SHA-2 certificate support.
 - 3. Remote access shall not require any inbound IP ports on the firewall to be "forwarded" or "exposed" to the Internet.
 - 4. The controls manufacturer shall update the secure remote access software on a regular basis and as necessary to comply with current cybersecurity best practices and respond to recent cyber security events.
 - 5. Users shall have administrator-defined access privileges. The system shall provide the capability to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
- G. The web browser interface shall provide a dashboard package that allows the operator to select dashboards to view, select as their homepage, or add to the their navigation tree.
- H. Storage of the graphical screens shall be in the network controllers without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
- I. Real-time values displayed on a web page shall update automatically without requiring a manual "refresh" of the Web page.

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2.5 CONTROLS SYSTEMS APPLICATIONS - GENERAL

- A. The System controllers shall include all monitoring, control and data handling controllers including programmable field panels and controllers.
- B. Controllers shall be programmable and governed by the requirements of their applicable codes, approvals and regulations for their application.
- C. The controllers shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.
- D. A failure at a controller shall not cause failures or non-normal operation at any other system controller other than the possible loss of active real-time information from the failed controller.
- E. Ancillary equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.
- F. Controllers shall comply with FCC Part 15 subpart J Class A emission requirements.
- G. Controllers shall maintain all programming in non-volatile or battery backed memory and shall automatically resume normal monitoring and control following the restoration of stable electrical power after a power outage.

2.6 CONTROLS SYSTEMS APPLICATION - SPECIFICS

- A. General:
 - 1. The Controls Systems shall be designed and implemented entirely for use and operation on the Internet and the Owner's Intranet. This functionality for operational access shall extend down to the field panel and field point level.
 - 2. The primary system controllers shall be fully IT compatible network nodes operating over the industry standard or existing IT infrastructure already existing in the building. The DDC Contractor shall coordinate with the Owner's IT infrastructure support staff to ensure compatibility and performance of the operation of the Controls Systems over the LAN/WAN made available for its shared use.
 - 3. The Controls Systems Tier 1 network shall be configured on IT industry standard off-the-shelf technologies compatible with other building systems and Project network arrangements.
 - 4. The DDC Contractor shall provide digital processor programmable Building Automation Server(s).

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5. All Controls Systems Application facilities and features shall be accessible via the Owners Intranet and Internet Browser with user ID or Password access control for user access.
 6. Controller to controller communication shall be by BACnet communications.
 7. The Controls Systems Application network shall utilize open Architecture as follows:
 - a. Standard Ethernet TCP/IP communications operating at a minimum speed of 10/100 Mb/sec.
 - b. BACnet/IP or BACnet Ethernet TCP/IP in accordance with ANSI/ASHRAE Standard 135 at the Tier 1 level.
 - c. BACnet MS/TP in accordance with ANSI/ASHRAE Standard 135 at the Tier 2 level.
 - 1) The Tier 2 level network may also use BACnet Ethernet TCP/IP and BACnet IP. BACnet IP shall only use private network IP addresses.
 - d. Proprietary communication protocols, LonTalk, and Fox communications are not acceptable.
 8. Downloading and Uploading:
 - a. Provide the capability to generate and modify the controls systems application software-based sequences, database elements, associated operational definition information and user-required revisions to same through the Web Interface together with the means to download same to the associated system controllers.
 - b. The controls systems application software tool provided for the generation of custom and database definitions shall be resident in both the systems controllers and controls systems application server(s).
 - c. Provide the capability to upload controls systems application operating software information, database items, sequences and alarms to designated server(s).
- B. Servers: Provide a building automation and controls system application server(s) as part of the fixed/desktop workstation, or in the form of a rack mounted server. Rack mounted servers shall be installed in a wall mounted, ventilated server cabinet with a hinged and lockable doors.
1. These server(s) shall be utilized for controls systems application configuration, for archiving historical data, reporting and trending of data, event histories, transaction logs, operator transaction archiving and reporting, network information management, alarm annunciation, operator interface tasks, for controls application management and the like. These server(s) shall utilize IT industry standard data base platforms such as Microsoft SQL Server, SQL Server Express, MySQL, Oracle 12C, Apache Derby, PostgreSQL, and Microsoft Data Engine (MSDE), or approved equal.

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- a. Storage capacity available for trend data, alarm or event histories, transaction logs, and similar data shall be no less than the equivalent amount required to store time-stamped trend data for every field control point on the control system every ten (10) minutes for one (1) year.
 2. Equip these server(s) with the same software tool set that is located in the primary controls systems controllers for system configuration and custom logic definition.
 3. Equip these server(s) with the same software tool set that is located in the primary controllers for color graphic configuration.
 4. Access to all information on the controls systems server(s) shall be through the same operator interface functionality used to access individual controllers. When logged onto a Server the operator shall be able to also interact with any of the primary controllers on the controls systems application.
- C. Operator Interface Software:
1. The operator interface provided shall include the functionality to selectively combine data and information from any system element or component in the controls systems application on a single browser window display panel at the operator's option. This shall include both current information and historical data stored on the server(s).
 2. The controls systems application OWS shall operate on Microsoft® Windows 10, Windows Server, Red Hat Linux, Ubuntu or other approved platform.
 3. Each controls systems application OWS shall be on-line configurable for specific functionalities and associated groups of system points and elements.
 4. Navigation Trees:
 - a. Provide the capability to display multiple navigation trees that aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the controls systems networks.
 - b. Provide the capability for the operator to add custom trees. The operator shall be able to define any logical grouping of systems or points and arrange them on the tree in any selected order. Provide the capability to nest groups within other groups. Provide at minimum for 5 levels of nesting.
 - c. The navigation trees shall be "dockable" to other displays in the operator interface including graphic displays. The trees shall appear as part of the display and may be individually detached and minimized to the Windows task bar or closed. Provide for a single keystroke to reattach the navigation tree to a primary display.
 5. Divisible Display Windows:

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- a. Provide for the operator to divide the display area within a single browser window into multiple display panels. The content of each display panel can be any of the standard summaries and graphics provided in the controls systems application.
 - b. Provide each display panel with minimize, maximize and close icons.
6. Alarms:
- a. Alarms shall be routed directly from primary system controllers to OWS and building automation server(s). Provide for specific alarms from specific points to be routed to selectable OWS and server(s).
 - b. The controls systems application shall annunciate systems diagnostic alarms indicating system failures and non-normal operating conditions.
 - c. Provide the on-line means to display alarms within the browser windows by date/time of occurrence, priority class, point designation, value or other defined text keywords.
 - d. The alarm management portion of the controls systems software shall, at minimum, provide the following functions:
 - 1) Log date and time of alarm occurrence.
 - 2) Generate a "Pop-Up" window on the browser display panel, with audible alarm, informing the Operator that an alarm has been received.
 - 3) Allow an operator, with the appropriate password, to acknowledge, temporarily silence or cancel an alarm.
 - 4) Provide an audit trail on hard drive for alarms by recording user acknowledgement, deletion or canceling of an alarm. The audit trail shall include the ID of the user, the alarm, the action taken on the alarm and a time/date stamp.
 - 5) Provide the ability to direct alarms to an e-mail address or cell phone via text message. This shall be provided in addition to the pop-up window described herein. An e-mail account for the Control System shall be provided on the Owner's e-mail server. Coordinate with the Owner's IT staff.
 - a) Custom Priority Programming: Establish a priority level to each alarm type, and dictate re-directs of alarms based on the priority level.
 - b) Alarm Segregation - System alarms to be sent to cell phones or e-mail based on categories and parameters such as: Type of alarm - HVAC (fans, pumps, temperature), MAINTENANCE (filters, runtime), LIFE SAFETY (Fire & smoke alarms), SECURITY (system security, intrusion &

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lighting override) CRITICAL (emergency generators & power distribution alarms). The system software shall perform alarm segregated routing, by type of alarm, to the appropriate personnel responding to the alarm condition.

- c) Alarm Suppression: Hierarchical alarm suppression methods described in the ASHRAE 36 shall be implemented.
 - d) System Scheduler: The system scheduler shall have the flexibility to accommodate vacations, holidays, equipment shutdowns, and personnel changes such. All schedules shall have the ability to be edited, viewed and printed.
 - e) Users shall have the ability to modify the phone number, email address, and message to be displayed through the controls system software.
 - f) Custom Time Programming: System time programming such as: Shift Alarms, Time of Day Alarms, Alarming Only While on Duty, and Weekend & Holiday Alarming.
- 6) Provide for any attribute of any object in the controls systems to be designated to report as an alarm, if so chosen by the user.
- 7) In addition to alarms specified in the sequences of operation, provide for the following additional, specific alarm types:
- a) Override alarms: Any point that is overridden through the override feature of the graphic workstation software shall be reported as an alarm.
 - b) HOA Switch Tampering Alarms: The sequences of operation are based on the presumption that VFD or motor starter Hand-Off-Auto (HOA) switches are in the auto position. If a motorized equipment unit starts without a prior start command from the DDC system, (as sensed by status sensing device), then DDC system shall perform the remaining sequence as specified.

7. Operator Transaction Archiving:

- a. Provide the means to automatically archive all operator activities on the Controls Systems Application and for the recall of same for reporting.
- b. Provide the means to sort and report archived activities by operator, date/time, activity type and system area.

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- c. Provide access protection to preclude the unauthorized removal or tampering with archived records.
 - d. Provide management support facilities for the deletion and re-initializing of archived record logs under master password control or equal means.
- 8. Reports:
 - a. Reports shall be generated and directed to one or more of the following: User interface displays, printers archived at the Owner's defined option. As a minimum, the controls systems application shall provide the following reports:
 - 1) All points in the controls systems application.
 - 2) All points in a specific system controller.
 - 3) All points in a user-defined group of points.
 - 4) All points currently in alarm.
 - 5) All points locked out.
 - 6) All controls systems application schedules.
 - 7) All user defined and adjustable variables, schedules, interlocks, diagnostics, systems status reports and the like.
 - b. Provide all applicable original manufacturers' standard reports for the controls systems.
 - c. Provide any custom reports as specified in Part 3.
- 9. Dynamic Color Graphics:
 - a. Create master floor plan (each floor) display from which other graphics may be selected.
 - b. Create one graphic page for each piece of mechanical equipment, including rooftop units, boilers, evaporative coolers, pumps, heat pumps, heat recovery units, etc.
 - c. Dynamic temperature, airflows, and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
 - d. Provide for any number of real-time color graphic displays. Graphics shall be able to be generated and displayed in the controls systems application limited only by memory data storage capacity.
 - e. Graphics shall be based on scalar vector graphic (SVG) technology.

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- f. Values of real-time attributes displayed on the graphics shall be dynamic and updated on the displays.
- g. The graphic displays shall be able to display and provide animation based on real-time data that is acquired, derived or entered into the operating Controls Systems.
- h. Provide for the Owner to be able to change values (setpoints) and states in system controlled equipment directly from the graphic display.
- i. Provide a graphic editing tool that allows for the creation and editing of graphic files. It shall be possible to edit the graphics directly while they are on line, or at an off line location for later downloading to the controller.
- j. Provide a complete user expandable symbol library containing all of the basic symbols used to represent components of a typical system. Implementing these symbols in a graphic shall involve dragging and dropping them from the library to the graphic.

10. Schedules:

- a. Provide multiple schedule input forms for automatic time-of-day scheduling and override scheduling of operations. At a minimum, the following spreadsheet types shall be accommodated:
 - 1) Weekly schedules.
 - 2) Temporary override schedules.
 - 3) Special "Only Active If Today Is a Holiday" schedules.
 - 4) Monthly schedules.
- b. Schedules shall be provided for each group, system and sub-system in the controls systems application. It shall be possible to include all or any 'commandable' points residing within the controls systems in any custom schedule. Each point shall have a unique schedule of operation relative to the system use schedule, allowing for sequential starting and control of equipment within the system. Scheduling and rescheduling of points shall be accomplished easily via the system schedule spreadsheets.
- c. Multiple monthly calendars for a 12-month period shall be provided that allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

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11. Historical Trending And Data Collection:

- a. Trend and store point history data for all actual and virtual (software) points and values as required by the Owner.
- b. The trend data shall be stored in a manner that allows custom queries and reports using industry-standard software tools.
- c. At a minimum, provide the capability to perform statistical functions on the historical database:
 - 1) Average.
 - 2) Arithmetic mean.
 - 3) Maximum/minimum values.
 - 4) Range - difference between minimum and maximum values.
 - 5) Standard deviation.
 - 6) Sum of all values.
 - 7) Variance.

12. Operator Access Security (Combined Password and User ID):

- a. Provide for Operator access into the Controls Systems via the use of on-line Owner defined software password and User Identification (ID) pairs, unique for each operator and unique throughout the controls systems application, to supplement standard password access control.
- b. Stored password/user ID definitions shall be stored in encrypted formats whether at the building automation controls server or at a controller.
- c. Password logins shall not be echoed on any screen or printer except during Master Password definition processes. An operator defining a password shall be required to re-enter to confirm authenticity.
- d. Operator access privileges shall be definable in terms of functions and project areas.
- e. As part of the access privileges definition for each user the Owner shall be able to define at minimum the following:
 - 1) Access times by day.
 - 2) Permanent or temporary, with expiry date, password.

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- 3) Number of incorrect access attempts allowed before the password is disabled.
- 4) Whether or not the operator is able to redefine their own password.
- 5) A field for the operator's e-mail address.
- 6) A field for the operator's contact phone number.
- 7) Definition of the operator's access privilege functionalities including viewing only, full control, selected functions, etc.

D. Controllers:

1. Controllers shall provide both standalone and networked direct digital control of mechanical and electrical building systems as required by the Contract Documents. The primary controller shall support a minimum of 10,000 total system field points together with all associated features, sequences, schedules, applications as required for fully functional distributed processing operations.
2. Each controller shall retain program, control algorithms, and setpoint information for at least seven (7) days in the event of a power failure and shall return to normal operation upon stable restoration of normal line power.
3. Each controller shall monitor and report its communication status to the Controls Systems Application. The Controls Systems shall provide a system advisory upon communication failure and restoration.
4. Controllers shall provide the functionality to download and upload configuration data, both locally at the controller and via the controls application networks.
5. Controllers shall perform the functional monitoring of all controls application variables, both from real hardware points, software variables, and controller parameters such as setpoints.
6. The primary controller shall manage and direct all information traffic on the Tier 1 network, between the Tier 1 and Tier 2 networks and to the building automation server(s).
7. All controllers on the Tier 1 network shall be equipped with all software and functionality necessary to operate the complete user interface, including graphics via a web browser connected to the controller on the network or directly via a local port on the controller.
8. The controller shall be designed, packaged, installed, programmed and commissioned in consideration of their specific service and prevailing operating conditions. They shall be proven standard product of their original manufacturer and not a custom product for this Project.

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9. A failure at a controller shall not cause failures or non-normal operation at any other system controller other than the possible loss of active real-time information from the failed controller.
10. Ancillary equipment, including interfaces and power supplies, shall not be operated at more than 80% of their rated service capacity.
11. Each controller shall retain program, control algorithms, and setpoint information in non-volatile memory in the event of a power failure, and shall return to normal operation upon restoration of power.
12. Each controller shall report its communication status to the application. The application shall provide a system advisory upon communication failure and restoration.
13. The controller shall incorporate the ability to download and upload configuration data, both locally at the controller and via the Application communications network.
14. Each primary controls systems controller shall be provided with the necessary uninterruptible power facilities to ensure its continued normal operation during periods of line power outages of, at minimum, 1 minute duration. This normal functionality shall include all normal software processing, communication with powered field devices and network communications with other powered system controllers, servers and OWS.

E. Special Software:

1. Event Messaging: Provide for the automatic execution of user-defined messages on the occurrence of each predefined real-time event including equipment/point status change, approaching limit or alarm, time of day and the like. Direct annunciation to Owner defined cell phone (text message), or e-mail address as required.
2. Optimum Start/Stop: Provide software to start equipment on a sliding schedule based upon indoor and outdoor conditions. Determine the minimum time of HVAC system operation needed to satisfy the space environmental requirements. The program shall also determine the earliest possible time to stop the mechanical systems. The optimum start/stop program shall operate in conjunction with, and be coordinated with, the scheduled start/stop and night setback programs.
3. Auto Alarm Lockout: Provide for scheduled and automatic lockout of alarm annunciation from equipment during non-normal operating conditions including shutdown, emergency power operation, filter alarm and the like.
4. Event Initiated Programs and Custom Logic: Provide software to define custom logic sequences that reside in the controller. This software shall also reside in the controller and be accessible to the standard operator interface via the browser.

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5. System Restart: Upon restoration of AC power to a controller, automatically restart all equipment and restore all loads to the state as required. Provide appropriate time delays to prevent demand surges or overload trips.
6. Heavy Load Delays: Provide software to achieve protection against excessive demand situations during start-up periods by automatically introducing time delays (i.e. staggered start) between successive start commands to heavy electrical or other defined loads.
7. Demand Limiting: System shall monitor building power consumption from building power meter pulse generator signals or from building feeder line watt transducer or current transformer. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand as specified in the sequences of operation. When demand drops below adjustable levels, system shall restore loads as specified.
8. Runtime Totalization: Automatically sample, calculate and store runtime hours for equipment start/stop binary input and operating status output points as listed in the points list or described in the sequence of operation].
9. Analog/Pulse Totalization: Sample, calculate and store consumption totals on a daily, weekly or monthly basis for user-selected analog and binary pulse input-type points.
10. Binary Totalization: System shall provide an algorithm that can totalize runtime for each binary input and object. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit.
11. Maintenance Management: System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified in the sequences of operation.
12. Anti-Short Cycling: Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.
13. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.
14. Energy and Utility Calculations:
 - a. System shall accumulate and convert (integrate) instantaneous power (kW) or flow/mass rates (gpm, lbs./hr) to energy usage data (gal, KWH, BTUs, etc.).
 - 1) Where an energy metering system is utilized, the calculations shall be performed by the energy meter.
 - b. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

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- c. System shall calculate a fixed-window average. Window interval start shall be defined by utility meter digital input signal to synchronize system's and utility's fixed-window averages.
- d. The displayed accumulated energy consumption value will not automatically reset, and will accommodate meter-rollover.
- e. Values shall only be reset (i.e. zero'ed) by system administrators.
- f. Calculations shall be adjusted for the fluid characteristics (e.g. percentage glycol), steam pressure, etc.

15. Automatic Fault Detection and Diagnosis (AFDD)

- a. AFDD software shall be provided to monitor the HVAC systems' performance to:
 - 1) Detect faults automatically
 - 2) Diagnose the cause(s) of a fault
 - 3) Enable alarms in the HCS that include a prioritized list of repair recommendations to building personnel.
- b. The AFDD software shall include algorithms that perform statistical analysis of fault trend data to develop repair recommendations
- c. The AFDD software shall sample HCS input measurements and output commands every 15 minutes.
- d. The AFDD software shall enable HCS alarms that identify current or projected HVAC system faults.
- e. The AFDD software shall send repair recommendations to building personnel via the Operator's WorkStation (OWS), and remotely as authorized by the Owner's IT department.

2.7 BACKUP POWER SOURCE AND CONTINUITY OF OPERATION AFTER ELECTRIC POWER INTERRUPTION

- A. HVAC systems and equipment served by a backup power source shall have associated DDC system products that control such systems and equipment also served from a backup power source. This shall include controllers, actuators, sensors, etc.
- B. UPS: DDC system products powered by uninterruptable power supply (UPS) units shall include the following:
 - 1. Web Servers.

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2. Desktop operator workstations.
 3. Building Automation Servers and Tier 1 Controllers.
 4. DDC controllers (Tier 2 and ASC's) serving equipment served by the emergency generator.
- C. Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.8 POWER CONDITIONING

- A. Protect DDC system products connected to ac power circuits from irregularities and noise rejection. Characteristics of power-line conditioner shall be as follows:
1. At 85% load, output voltage shall not deviate by more than ± 1 percent of nominal when input voltage fluctuates between minus 20 percent to plus 10 percent of nominal.
 2. During load changes from zero to full load, output voltage shall not deviate by more than ± 3 percent of nominal.
 3. Accomplish full correction of load switching disturbances within five cycles, and 95 percent correction within two cycles of onset of disturbance.
 4. Total harmonic distortion shall not exceed 3-1/2 percent at full load.
- B. Ground Fault: Protect products from ground fault by providing suitable grounding. Products shall not fail due to ground fault condition.

2.9 CONTROL PANELS

- A. Provide control panels with suitable brackets for wall mounting for each control system. Locate panel adjacent to systems served.
1. Fabricate panels of 16-gage furniture-grade steel, totally enclosed on four sides, with piano hinged door and keyed lock, with manufacturer's standard shop-painted finish and color.
 2. Provide UL-listed cabinets for use with line voltage devices.
 3. All panels powered by 120VAC circuits shall be provided with surge protection. This protection is in addition to any internal protection provided by the controller

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manufacturer. This protection shall meet UL, ULC 1449, IEEE C62.41B. A grounding conductor (min. 12 AW.G) shall be brought to each control panel.

4. All control panels shall have a circuit breaker and available duplex outlet.
5. Control Transformers: Provide as required. Transformer loading shall not exceed 60% of capacity. All control transformers shall include primary and secondary circuit protection. Maintain enclosure environmental temperature within transformer operating range as recommended by transformer manufacturer.
6. Control panel shall be completely factory wired and piped, and all electrical connections made to a terminal strip. Control panel shall have standard manufacturer's color.
7. All gauges and control components shall be identified by means of nameplates.
8. All control tubing and wiring shall be run neatly and in an orderly fashion in open slot wiring ducts with cover.
9. Conduits shall not enter the top of panels.
10. Do not loop or coil excess wire in cabinet.
11. There shall be no drilling on the controller cabinet after the controls are mounted inside.
12. Careful stripping of wire while inside the cabinet is required to ensure that no wire strand fragments land on circuit boards.
13. Complete wiring and tubing termination drawings shall be mounted in or adjacent to each panel.
14. Indoor cabinets shall be NEMA 1 construction, unless noted otherwise. Cabinets located outdoors shall be NEMA 4X.
15. A paper copy of the system control schematics from the as-built documentation, including I/O lists, control diagram identifying devices, etc., shall be provided in a plastic sleeve secured to the inside of the control panel door. A laminated, reduced size of the control diagram shall also be installed on the outside face of the panel.

2.10 SEPARABLE SOCKETS (THERMOWELLS)

- A. Comply with requirements Division 23 Section "Meters and Gages for HVAC Piping", including the use of heat-transfer compound.

2.11 PIPING, TUBING, AND VALVES

- A. Water and Air Pressure Instrument Signal Tubing and Piping:

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1. Products in this paragraph are intended for use with the following:
 - a. Pressure signals to instruments connected to hydronic systems.
 2. Copper Tubing:
 - a. Seamless phosphor deoxidized copper, soft annealed or drawn tempered, with chemical and physical properties according to ASTM B 75.
 - b. Performance, dimensions, weight and tolerance according to ASTM B 280.
 - c. Diameter, as required by application, not less than nominal 0.25 inch.
 - d. Wall thickness, as required by the application, but not less than 0.030 inch.
 3. Copper Tubing Connectors and Fittings: Brass, compression or solder joint type.
- B. Steam System Tubing: Products in this paragraph are intended for signals to pressure instruments connected to steam systems.
1. Stainless-Steel Tubing: Seamless Type 316 stainless steel, Grade TP, cold drawn, annealed and pickled, free from scale.
 - a. Chemical and physical properties according to ASTM A 269.
 - b. Diameter, as required by application, of not less than nominal 0.25 inch.
 - c. Wall thickness, as required by application, but not less than 0.035 inch.
 2. Stainless-Steel Tubing Connectors and Fittings: Connectors and fittings shall be stainless steel, with stainless-steel collets, flareless type. Connect instruments to tubing with connectors having compression connector on one end and IPS or NPT thread on other end.
- C. Air Static Pressure Tips:
1. Duct Applications: Constructed of brass or stainless steel tubing, with a mounting flange and a 90 degree bend, with four (4) 0.040" diameter, radially drilled sample holes located near the tip and set a minimum of 4" away from the duct or plenum wall. Dwyer A-301 or A-302 series, or approved equal.
 - a. Stainless steel shall be used in laboratory exhaust applications.
 2. Indoor Room Pressure Applications: Constructed of stainless steel, with a mounting flange for finished ceiling or wall installation. Dwyer A-414 or approved equal.

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3. Outdoor Building Pressurization (Differential Pressure Measurement) Applications: Dwyer A-306 series probe for the low (outdoor) side with a Modus pneumatic surge dampener piped to both the high and low ports, or approved equal. Locate the outdoor probe as far away from building walls and other turbulence inducing objects/ obstructions as possible. Terminate the indoor probe in the ceiling space. The differential pressure sensor shall be located indoors and piping extended to the outdoor probe.
- D. Pressure Snubbers: Comply with requirements Division 23 Section "Meters and Gages for HVAC Piping".
- E. Manual Valves: Needle Type. Comply with requirements in Division 23 Section "Meters and Gages for HVAC Piping".
- F. Syphons: Comply with requirements in Division 23 Section "Meters and Gages for HVAC Piping".

2.12 CONTROLS SYSTEMS FIELD DEVICES

- A. Input Devices:
 1. Airflow Low Differential Pressure Switch:
 - a. Rating: NEMA 1
 - b. Mounting: Duct Insertion.
 - c. Range: 0.05" to 5.0" WC, complete with field adjustable setpoint.
 - d. Protection: Overpressure to 1 PSIG
 - e. Output: Form C Contact, minimum 50VA
 - f. Reset: Automatic or manual reset as required by the sequence of operation.
 - g. Accessories: Provide complete installation kit including static pressure tips, tubing, fittings and air filters.
 2. Airflow High Differential Pressure Switch:
 - a. Rating: NEMA 1
 - b. Mounting: Duct Insertion
 - c. Range: 1" to 10" WC, complete with field adjustable setpoint
 - d. Protection: Overpressure to 1 PSIG
 - e. Output: 2 Form C Contacts, minimum 360VA

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- f. Accessories: Provide complete installation kit including static pressure tips, tubing, fittings and air filters.
3. Space-to-Space and Space-to-Outdoor Air Low Differential Pressure Transducer:
- a. Product: Ebtron 'EF-x2000-B' series bleed-orifice type differential pressure sensor and transmitter, no substitutions.
 - b. Mounting: Ceiling-space/plenum mounted, unless room mounting is indicated on the Drawings. 50 Ft long plenum rated cable between sensor and transmitter.
 - c. Range: -0.5 to +0.5 (inches of Water Column).
 - d. Accuracy: 2% of reading.
 - e. Sensitivity: 0.0002 inches w.g.
 - f. Thermal Effect Compensation Range: -20 to 120 Degrees F
 - g. Output: 0-5 or 0-10 VDC, linear.
 - h. Network Interface: BACnet MS/TP.
 - i. User Interface: LCD display.
 - j. Warranty: 3 years.
 - k. Installation for Space to Space Sensing: Pipe each end of the sensor with copper tube matching the sensor connection size. Do not exceed maximum tubing length recommended without increasing pipe size as recommended by the manufacturer. Where tubing requires upsizing, also perform the manufacturer-recommended field adjustments or calibration. Provide mesh screened wall/ceiling plates on each side of the sensor.
 - l. Installation for Space to Outdoor Air Sensing: Locate the sensor and transmitter indoors. Pipe each end of the sensor with copper tube sized as recommended by the manufacturer for the length of run and number of fittings proposed. Provide mesh screened wall/ceiling plates on each side of the sensor. Provide a stainless steel rain shield for the exterior termination. Paint the rain shield with exterior grade polyurethane paint matching the adjacent building surface color. Perform the manufacturer-recommended field adjustments or calibration.
4. Standard Accuracy Air Differential Pressure and Static Pressure Sensors:
- a. Enclosure Rating: NEMA 1 (indoors) or 4X (outdoors). Installing exterior units inside a field-provided NEMA 4X enclosure is also acceptable.
 - b. Accuracy: +/- 0.5% of natural span.

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- c. Mounting: Duct Insertion
 - d. Range: 0.05" to 5.0" WC
 - e. Protection: Overpressure to 1 PSIG
 - f. Output: 0-10vDC, 4-20mA
 - g. Accessories: Provide complete installation kit including static pressure tips, tubing, fittings and air filters.
5. Water Differential Pressure Transducer With Three Valve Manifold (for pump VFD control):
- a. Provide differential pressure transmitter with three-valve Manifold.
 - b. Rating: NEMA 1.
 - c. Mounting: Pipe mounted.
 - d. Range: 0-25 PSI unidirectional
 - e. Accuracy: +/-0.25% of full scale.
 - f. Protection: 150 PSIG
 - g. Output: 4-20mA, 0-5 VDC, 0-10 VDC.
 - h. Accessories: Needle valves and snubbers.
 - i. Acceptable Manufacturer:
 - 1) Transducer: Kele Model # 230, or approved equal by Veris.
 - 2) Three valve manifold: Kele Model # M230-3VLV, or approved equal.
6. Water Differential Pressure Switch:
- a. Materials: Brass bellows.
 - b. Mounting: Pipe mounted.
 - c. Range: 2-26 PSI, 1.2 PSI fixed differential.
 - d. Protection: 120 PSI Differential overpressure, 180 PSI static pressure.
 - e. Output: Form C contacts, 50 VA
 - f. Special: Pipe taps and shut off valves provided by Div. 23.
7. Pipe Liquid Pressure Sensors:

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- a. Construction: Wetted parts of transmitter constructed of Type 316 stainless steel.
 - b. Range: Minus 0 to 300 psig.
 - c. Span: Field adjustable.
 - d. Minimum Span: 3 psig.
 - e. Accuracy: Within 0.1% of span.
 - f. Process Temperature Limits: Minus 40 to 250 deg. F.
 - g. Ambient Temperature Limits: Minus 40 to 185 deg. F.
 - h. Analog Output: Two-wire, 4- to 20-mA.
 - i. Transmitter Enclosure: NEMA 250, Type 4X.
 - j. Accessories: Needle valves and snubbers.
8. Pipe Steam Pressure Sensors: As specified above for liquid pressure sensors, but provided with a pigtail steam syphon and pressure snubber between the pipeline and the sensor. Provide additional length of uninsulated tubing between the syphon and sensor to prevent the sensor's temperature rating from being exceeded. Prime syphon prior to startup and pipe in a manner such that condensate regularly formed in the line will maintain a seal in the syphon.
9. Pipe Liquid Temperature Sensors for Energy Metering or Calculation Applications:
- a. Sensor type: Platinum 1000 Ohm RTD.
 - b. Temperature Range: -94 to 572 deg. F.
 - c. Wetted Parts: Type 316L stainless steel.
 - d. Accuracy: 0.02% of span.
 - e. Minimum span: 18 deg. F.
 - f. Stability: 0.25% over 5 years.
 - g. Display: LCD.
 - h. Analog Output: Two-wire, 4- to 20-mA.
 - i. Transmitter Enclosure: NEMA 250, Type 4X.
 - j. Ambient Temperature Limits: Minus 40 to 185 deg. F.
 - k. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

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- 1) Rosemount '3144P'
 - 2) Approved equal.
10. Pipe Liquid Temperature Sensors other than those used for energy metering: Platinum 1000 Ohm RTD or thermistor type.
- a. Materials: Stainless steel sheath.
 - b. Range: -50°F to 250°F
 - c. Accuracy: 0.1%
 - d. Drift: Within 0.5 deg. F. over 10 years.
 - e. Installation: In thermowell with heat transfer compound.
11. Pipe Steam Temperature Sensors: Platinum 1000 Ohm RTD type.
- a. Materials: Stainless steel sheath.
 - b. Range: -50°F to 500°F
 - c. Pressure Limit: 3,000 psig.
 - d. Accuracy: 0.1%
 - e. Drift: Within 0.5 deg. F. over 10 years.
 - f. Manufacturer: Minco, or approved equal.
12. Duct or Plenum Low Temperature Switches (FreezeStats): Capillary tube type with continuous sensing of temperature. Freezestats with discrete temperature sensing points are not acceptable.
- a. The low temperature limit switch shall be of the automatic reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.
 - b. The sensing element of each freezestat shall be a minimum of 20 feet in length and shall react to the coldest 12 inch section.
13. Duct High Temperature Switches:
- a. The high temperature limit switch shall be of the automatic reset type with Single Pole or Double throw that opens with rise in temperature.
 - b. Unit shall be UL approved

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- c. Unit shall have an adjustable set point from 100 to 250 Degrees F with a 25 Degrees F differential deadband.
 - d. The sensing element shall be 5" or 11" in order to fit the application.
 - e. High Temperature Limit Switch shall be Kele Model TC-105 or TC-100, or approved equal.
14. Duct Temperature Sensors (Single Point): Platinum 1000 Ohm RTD type.
- a. Materials: Nickel element in a copper sheath.
 - b. Range: -50°F to 250°F
 - c. Accuracy: 0.1%
 - d. Drift: Within 0.5 deg. F. over 10 years.
 - e. Special: Duct element holder, gasket, and cover.
 - f. Element Length: Shall span at least 33% of the duct.
15. Duct and Plenum Temperature Sensors (Averaging): Platinum 1000 ohm RTD type, with continuous wire strands to provide average temperature across entire length of sensor element. Averaging sensors with discrete sensing points (i.e. thermistor type) are not acceptable. The sensor shall have a sintered moisture protection coating protecting against condensation, mechanical stress, and vibration.
- a. Range: -50°F to 250°F
 - b. Accuracy: 0.1%
 - c. Drift: Within 0.5 deg. F. over 10 years.
 - d. Special: Probe brackets to support turns in the element and prevent vibration during system operation.
 - e. Length: As required by application to cover entire cross section of air tunnel or duct. The length of the averaging bulb shall be sufficient to cover the free area from top to bottom. Each pass of the bulb shall not exceed 12 inches from the previous
16. Relative Humidity Sensors: Thin-film capacitive type or complementary metal oxide semiconductor (CMOS) type, with nonvolatile memory.
- a. Mounting: Duct or Wall.
 - b. Range: 10% to 90%.
 - c. Accuracy: +/-5% of full scale, unless otherwise specified.

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- d. Long Term Drift: +/- 0.25%
 - e. Protection: 0-100% non-condensing.
 - f. Output: 0-10vDC, 4-20mA.
 - g. Special: Duct or wall mounting kit.
 - h. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Belimo
 - 2) Vaisala
 - 3) BAPI
 - 4) Setra
 - i. Wall Mounted Relative Humidity Sensors in Public Occupied Spaces: Space relative humidity shall be monitored by vandal-proof, flush-mount, stainless steel wall plate type sensors. The plate shall have no logos, and shall be single-gang size. The sensor shall be placed at perforations in the plate. Under no circumstances shall a conventional humidity sensor be utilized in public spaces.
 - 1) The following shall be considered 'public occupied spaces': Main/public corridors, toilet rooms, break rooms, open offices, stairways, vestibules, and the lobby.
17. Dewpoint Sensors: Units shall be suitable for duct, wall (room) or outdoor mounting. Units shall be two-wire transmitters utilizing bulk polymer resistance change or thin film capacitance change humidity sensors. Units shall produce linear continuous output of 4-20 mA for dewpoint temperature (°F). Sensors shall have the following minimum performance and application criteria:
- a. Accuracy: +/- 1.8°F;
 - b. Sensor Operating Range: As required by the application;
 - c. Long Term Stability: Less than 1% drift per year;
 - d. Digital display.
 - e. Acceptable Manufacturers: Vaisala, or approved equal.
18. DDC System Room Thermostats or Temperature Sensors:
- a. Room thermostats shall be compatible with the zone controller.

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- b. The temperature sensor shall be a IEC 751 Class A or B 1,000 Ohm platinum or nickel RTD. Thermistors are not acceptable.
 - 1) Resolution: +/- 0.2 deg. F.
 - 2) Accuracy: +/- 0.5 deg. F. at 77 deg. F. (25 deg. C.)
 - 3) Temperature Limits: -40 deg. F. to 120 deg. F.
 - 4) Temperature Range: As required by application, but no less than 32 deg. F. to 104 deg. F.
 - 5) Drift: No more than 0.3 deg. F. over 5 years.
- c. Thermostats in public occupied spaces: Space temperature shall be monitored by vandal-proof, flush-mount, stainless steel wall plate type sensors. The plate shall have no perforations or logos, and shall be single-gang size. The sensor shall be placed in contact with the front plate, and provided with min. 1/4" thick closed cell foam insulation backing to insulate the sensor from the wall temperature.
 - 1) The following shall be considered 'public spaces': Main/public corridors, toilet rooms, break rooms, stairways, vestibules, and the lobby.
- d. Thermostats in non-public, occupied spaces shall have a setpoint slider, dial, or pushbuttons (with remote adjustability limiting) and an occupied/unoccupied over-ride switch.
 - 1) Thermostats in non-public spaces shall be provided with room setpoint and current space temperature readout (backlit LCD display) integral to the main body of the thermostat. The setpoint value shall be the actual value, not a
- e. Integration of Additional Sensors:
 - 1) Where space temperature and CO2 sensors are indicated on the drawings in the same location, a combined thermostat and CO2 sensor in a single enclosure shall be utilized. The combined device shall be installed in a single gang box. The use of two separate devices is not acceptable.
 - 2) Where space temperature and relative humidity sensors are indicated on the drawings in the same location, a combined thermostat and humidity sensor in a single enclosure shall be utilized. The combined device shall be installed in a single gang box. The use of two separate devices is not acceptable.]
 - 3) Where space temperature, relative humidity, and CO2 sensors are indicated on the drawings in the same location, at least one wall mounted device used

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shall combine more than one sensor into a single enclosure, so that no more than two devices are used. Each device shall be installed in a single gang box. The use of three separate devices is not acceptable.

19. Piping Clamp-On Aquastat: UL listed, provided with a suitable removable spring clip for attaching aquastat to pipe and a snap-action SPDT switch. Adjustable Range: 65 to 200 deg. F. Adjustable Differential: 5 to 30 deg. F. Electrical rating shall be 5 FLA, 120 VAC.
20. Piping Clamp-on Temperature Sensor: 10K ohm, type 3 thermistor or 1K platinum RTD, with plastic or metallic housing suitable for piping outer diameters up to 3.5" and conduit connection. 4-20mA or 0-10 VDC output, with temperature range suitable for the application. Attach to pipe with stainless steel straps. Provide heat conductive paste if recommended by sensor manufacturer.
 - a. Strap-on sensors shall only be used when specifically indicated on the Drawings or sequences of operation.
21. Damper Position Switches (End Switches): Encapsulated (non-mercury) switch mounted on the damper crank arm. The use of auxiliary contacts on the actuator to indicate position is not acceptable. The switch shall be able to be mounted on a damper control shaft to give an indication of opened and closed damper position. The switch shall be open when the cable end of the switch is horizontal or above. The switch shall make when the cable end drops more than 15 degrees below horizontal. The unit shall have two (2) SPDT switches, plenum rated cable, and stainless steel housing.
 - a. Switch shall be rated for outdoor use and rated at a minimum of 2A @ 120VAC
 - b. Acceptable Manufacturer: Kele 'TS-475' series, or approved equal.
22. Vibration Switches:
 - a. Acceleration sensitive devices that measure the total peak vibratory shock. The device shall provide electric switch contact closure for shutdown of fans, pumps, or compressors. The device shall be DPDT for direct wiring to the equipment and to the DDC system.
 - b. The setpoint shall be field adjustable between 0 and 4.5 Gs in a frequency range of 0 to 50 Hz. The device shall be automatic reset. The setpoint shall be as recommended by the equipment (e.g. fan) manufacturer.
 - c. The main set of contacts shall be wired directly to the fan, pump, or compressor starter; the auxiliary set shall be wired to the DDC system.
 - d. Manufacturer: Vibra-Alert Model 5173 or 5175 vibration switches, or approved equal.

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23. Airflow Switch: Two-port operating a spring loaded diaphragm with adjustable setpoint activated by air pressure, incorporating protection against three times working pressure, and switching dry contacts.
24. Water Flow Switch (Electronic Type):
 - a. Type: Thermal dispersion principle, incorporating no moving parts. Sensor head shall employ two temperature sensors and a low power heating source. Sensors shall be suitable for up to 350 deg F. fluid.
 - b. Construction: 316L stainless steel wetted parts. NEMA 4X electronics housing.
 - c. Rangeability: 300:1
 - d. Input Power: 24VDC.
 - e. Outputs:
 - 1) Two (2) sets of dry contacts rated at 3A each for flow detection, with independent, adjustable switching setpoints.
 - 2) 4-20 mA output for temperature.
 - f. Acceptable Product: Ameritrol Inc. "FX" series, or approved equal.
25. Current Switch:
 - a. Materials: Encased copper.
 - b. Rating: 600vAC.
 - c. Mounting: Split Core.
 - d. Range: 1.5 amps to 50 amps.
 - e. Action: Trip point adjustment.
 - f. Output: SPST, N.O.
 - g. Special: Status LED
26. Remote Current Switch or Command Relay Combination:
 - a. Mounting: Panel or Electrical Box
 - b. Range: .5 to 16 Amps
 - c. Trip Set-point: Adjustable
 - d. Sensor Power: Induced

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- e. Max. Operating Voltage: 250 VAC
 - f. Frequency Range: 50/60 Hz.
 - g. Humidity Range: 0 to 95% non-condensing
 - h. Operating Temperature: -15° to 60°C
 - i. Status Output: 1.0A @ 30 VAC/DC
 - j. Switch shall have HOA switch to override and troubleshooting
 - k. Switch shall include belt loss detection feature.
 - l. Manufacturer: Hawkeye H548 series, or approved equal
27. Current Transducer:
- a. Mounting: Field Mounted.
 - b. Range: 60 Hz nominal.
 - c. Accuracy: +/-2% full scale.
 - d. Protection: 250 A max current.
 - e. Output: 4-20mA.
28. Hydronic Water Flow Metering (Vortex Shedding Type):
- a. Flow transmitters shall be of a two-wire 4-20 mA type, operating on a vortex shedding principle and provide a current signal linear with flow.
 - b. Insertion type meter, complete with hot-tap isolation valves to enable sensor removal without water system shutdown. Sensor housing shall have full port Type 316 stainless-steel ball valve for system isolation.
 - c. Transmitters shall be factory wet calibrated, field calibration or adjustment is not permitted. The transmitter shall be protected against damage from reverse polarity and line transients. The transmitter shall meet the following specifications:
 - 1) Accuracy: +1.0 percent of rate
 - 2) Repeatability: 0.2 percent of span
 - 3) Rangeability: 20:1
 - 4) Temperature Limits: -40°F to +400°F
 - 5) Ambient: -40°F to +150°F

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- d. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) ONICON Inc. 'F-2700' Series
 - 2) Rosemount/ Emerson Electric '8800D' Series
 - 3) Badger Meter 'VN 2000' Series
29. Hydronic Water Flow Metering (Insertion Turbine or Impeller Type):
- a. Dual counter-rotating axial turbine elements, each with its own rotational sensing system, and an averaging circuit to reduce measurement errors due to swirl and flow profile distortion. Flow sensing turbine rotors shall be non-metallic and not impaired by magnetic drag.
 - 1) Single turbine is acceptable for piping 2 inches and smaller.
 - 2) Single turbine is acceptable for specific product series listed below that are single turbine type.
 - b. Insertion type meter, complete with hot-tap isolation valves to enable sensor removal without water system shutdown. Sensor housing shall have full port Type 316 stainless-steel ball valve for system isolation.
 - c. Sensing method shall be impedance change sensing (e.g. non-magnetic and non-photoelectric).
 - d. Volumetric accuracy:
 - 1) $\pm 0.5\%$ of reading at calibrated velocity
 - 2) $\pm 1\%$ of reading from 3 to 30 ft./s (10:1 range)
 - 3) $\pm 2\%$ of reading from 0.5 to 20 ft./s (40:1 range)
 - e. Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which shall be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
 - f. Maximum operating pressure of 400 psi and maximum operating temperature of 200 deg. F continuous (220 deg. F. peak).
 - g. All wetted metal parts shall be constructed of Type 316, 17-4PH, or 18-8 stainless steel.

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- h. Analog outputs shall consist of non-interactive zero and span adjustments, a DC linearity of 0.1% of span, voltage output of 0-10 VDC, and current output of 4-20 mA.
 - i. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Badger Meter - 'SDI' series
 - 2) Approved Equal by:
 - a) ONICON Inc.
 - b) Spirax-Sarco
 - c) VorTek Instruments LLC
30. Hydronic Water Flow Metering (Ultrasonic or Transit Time Type):
- a. Clamp-on transit-time ultrasonic flowmeter complete with matched transducers, self-aligning installation hardware and transducer cables.
 - b. Local Display: 2-line x 8-character LCD; LED backlighting, with keypad.
 - c. Output: 4-20 mA transmitter proportional to flow or velocity.
 - d. Accuracy: 1.0% of reading in range 0.1 to 30 ft./sec., 0.001 ft./sec. sensitivity.
 - e. Ultrasonic transducers provided shall be optimized for the specific pipe & process conditions for each application and the transducer frequency shall be automatically matched to the resonant frequency of the pipe at start-up.
 - f. Accessories: Stainless steel mounting straps and silicone grease.
 - g. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Dynasonics, Division of Badger Meter Inc. - 'TFX or TFXL' Series
 - 2) Approved Equal By:
 - a) Flexim
 - b) ONICON Inc.
 - c) Siemens
 - d) VorTek Instruments LLC
 - e) Belimo

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31. Hydronic Energy Metering Systems: The entire hydronic energy metering system shall be built and calibrated by a single manufacturer and shall consist of a flow meter, two temperature sensors, a BTU calculator, transmitter, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST* traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer's two (2)-year warranty.
- a. The flow meter shall be of the ultrasonic or transit-time or turbine meter type as specified above. The flow meter shall be installed in the system piping following the manufacturer's instructions with particular attention paid to upstream and downstream straight pipe runs.
 - b. BTU Calculator and Transmitter: Digital signal processor module with non-volatile EEPROM solid state memory to integrate raw measurement data and compute volumetric flow rate and total and an LCD display.
 - 1) Transmitter Enclosure: NEMA 250, Type 4 or 4X.
 - 2) Ambient Temperature Limits: Minus 40 to 185 deg. F.
 - 3) Local Display: 2-line x 8-character LCD; LED backlighting, with keypad.
 - 4) Power: 120VAC or 24 VDC.
 - 5) Output: BACnet MS/TP or BACnet IP interface to the DDC system for the following points:
 - a) Temperature (two points)
 - b) Flowrate (GPM)
 - c) Energy (Tons or MBH-hrs.)
 - c. Temperature sensors: Temperature sensors shall be RTD type, loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST* traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within +0.15°F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).
 - 1) Wetted Parts: Type 316L stainless steel.
 - 2) Minimum span: 18 deg. F.
 - 3) Stability: 0.25% over 5 years.

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- d. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) ONICON Inc.
 - 2) Badger Meter
 - 3) Approved Equal.
32. Steam Flow Meters (Vortex Shedding Type):
- a. Steam meters shall operate on a vortex shedding principle. Meter shall be both temperature and pressure compensated and shall produce a readout in mass flow rate. Mass flow inferred from specified steam pressure or calculated externally to the flow meter is not acceptable.
 - b. In-line type with ANSI Class 150 flanged ends or Insertion type, complete with hot-tap isolation valves to enable sensor removal without water system shutdown. Sensor housing shall have full port Type 316 stainless-steel ball valve for system isolation. Type 316L stainless steel construction and wetted parts.
 - c. Transmitters shall be factory wet calibrated (min. 5 point calibration); field calibration or adjustment is not permitted. The transmitter shall be protected against damage from reverse polarity and line transients. The transmitter shall meet the following specifications:
 - 1) Accuracy: +/- 1.5 percent of mass rate.
 - 2) Repeatability: +/-0.2 percent of span.
 - 3) Rangeability: 38:1
 - 4) Transmitter Output:
 - a) 4-20 mA mass flow rate
 - b) Totalized, pulse output of mass flow rate.
 - c) Temperature
 - d) Pressure
 - d. Metered Media Temperature Limits: -40°F to +460°F
 - e. Ambient Temperature Limits: -40°F to +150°F
 - f. Local Display: 2 line, 10 character LCD, for remote mounting with min. 32 ft. long cable.

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- g. Serial Network Interface: BACnet MS/TP.
 - h. Accessory: Flow straightener, installed upstream of meter.
 - i. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following products:
 - 1) ONICON Inc. "F-2600" or "F-2700" series
 - 2) Approved equal by:
 - a) Badger Meter Inc.
 - b) Rosemount, a Division of Emerson Electric Co.
 - c) Spirax Sarco
 - d) VorTek Instruments LLC
33. Fuel Oil Flow Meters:
- a. Type: Positive displacement type. Wetted parts shall be suitable for use with #2 fuel oil.
 - b. Accuracy: +/- 2% for entire normal operating range.
 - c. Accessory: Provide plate type strainer screen in inlet of meter.
 - d. Maximum working pressure: 275 psig at 80 deg. F.
 - e. Local Register: Direct reading on top of meter, with protective cover.
 - f. Remote Display: Provide LCD display to indicate flow rate and totalized flow (field selectable) with engineering units displayed. Display may be remote mounted up to 200 feet from the meter.
 - g. Signal Output: Scalable pulse output for totalization.
 - h. Acceptable Manufacturer: Badger Meter 'IOG' series, or approved equal by Contoil.
34. Natural Gas Flow Meters (Mass Flow Meter):
- a. General Requirements: Provide an insertion type thermal dispersion type flow meter, complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown, including a full port ball valve suitable for natural gas service.

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- 1) For pipe sizes smaller than 1½" provide an inline type meter in lieu of insertion type.
 - 2) Provide a flow conditioner upstream of the meter. The conditioner may be integral to the meter or separately installed in the piping system.
- b. Construction Features:
- 1) Process Wetted Parts: All welded Type 316L stainless steel, Teflon ferrule (rated to 150 psig and 200°F), or Stainless Steel Ferrule (rated to 250 psig and 350°F).
 - 2) Flow element Enclosure: Explosion proof Class I, Division II.
 - 3) Remote Electronics Enclosure: Explosion proof Class I, Division II.
- c. Performance Specifications:
- 1) Microprocessor based.
 - 2) Accuracy: ±1 percent of rate from 500-7000 SFPM, and + 2 percent from 100 to 500 SFPM. Overall turndown shall exceed 1000:1.
 - 3) Repeatability: ± 0.5% of reading.
 - 4) Signal Output: 4-20 mA dc, and scalable pulse output for totalization.
 - 5) Operating Pressure: 0 to 250 psig.
 - 6) Flow Element Range: 0.75 to 600 SFPS at standard conditions.
 - 7) Input Power:
 - a) AC Input: 85 to 260 VAC, 60 Hz, 17-Watts Maximum; 120 mA Maximum.
 - b) DC Input: 22 to 30 VDC 7.5-Watts Maximum; 250 mA Maximum.
 - 8) Operating Temperature:
 - a) Flow Element: -40 to 350° F.
 - b) Electrical Housing: 0 to 140° F
 - 9) Calibration: Factory calibrated at specified flow range under given conditions, in NIST traceable flow stands. Calibration data sheet to be provided with each meter.

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- d. Local Display: Provide digital LCD display to indicate flow rate and process temperature or totalized flow (field selectable) with engineering units displayed. Display may be remote mounted up to 500 feet from the sensor.
 - e. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following products:
 - 1) Fluid Components International LLC (FCI) 'ST98 FlexMASster' Series
 - 2) ONICON Inc. 'F-5500' Series
 - 3) Sage Prime 'Thermal Mass Flow Meter'
35. Domestic Water Flow Metering (Turbine Type)
- a. Type: Flanged or insertion type meter with turbine flow element. Flanged meters shall have a cast bronze or stainless steel main case. All materials shall be completely lead free and the meter shall meet NSF /ANSI Standard 61.
 - 1) Insertion Mounting: Meter shall be complete with hot-tap isolation valves to enable sensor removal without water system shutdown. Sensor housing shall have full port Type 316 stainless steel ball valves for isolation.
 - b. Accuracy:
 - 1) AWWA Class II measuring element meeting accuracy requirements of AWWA C701 (+/- 1.5% for entire normal operating range). The 'normal operating range' shall extend to flows as low as 2.5 gpm in sizes 3" and smaller; and 6 gpm in sizes up to 10".
- OR
- 2) Each sensor shall be individually calibrated and tagged accordingly against the manufacturer's primary standards which shall be accurate to within 0.1% of flow rate and traceable to the National Institute of Standards and Technology (NIST).
 - a) 0.5% of reading at calibrated velocity
 - b) $\pm 1\%$ of reading from 3 to 30 ft./s (10:1 range)
 - c) $\pm 2\%$ of reading from 0.4 to 20 ft./s (50:1 range)
- c. Maximum working pressure: 175 psig at 80 deg. F.
 - d. Interchangeable measuring element for in-line service.

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- e. Output: Scalable pulse output for totalization.
 - f. Local Register: Direct reading on top of meter, with protective cover.
 - g. Remote Display: Provide LCD display to indicate flow rate and totalized flow (field selectable) with engineering units displayed. Display may be remote mounted up to 500 feet from the sensor.
 - h. Acceptable Manufacturers: Subject to compliance with requirements, provide one of the following products:
 - 1) Neptune Technology Group 'HP Turbine Meter' with 'TRICON/E3' Series Transmitter (flanged type)
 - 2) Badger Meter 'SDI' Series (insertion type)
 - 3) ONICON Inc. 'F-1100' Series (insertion type)
 - 4) Sensus 'T2' Series (flanged type)
36. Duct, Plenum, and Un-ducted Air Intake Mounted Airflow Measuring Stations: Multiport, self-averaging thermal dispersion tube station using sealed thermistors. Sensor density shall be no less than that required to produce the sensing accuracy specified below for the installed conditions of this Project. Each thermistor pair location shall independently measure velocity of the airstream, and the transmitter shall average those velocities for overall airflow rate measurement. Stations using RTDs are not acceptable.
- a. Power Requirement: 24 VAC.
 - b. Calibrated Velocity Range: 0 to 5000 fpm.
 - c. Sensing Point Accuracy:
 - 1) Flow: $\pm 5\%$ of reading in installed system, and on each individual sensor, with a NIST traceable factory calibration on each sensor. Accuracies shall be over a range of zero (0) to 5,000 feet per minute (fpm) air velocity.
 - 2) Temperature: $\pm 0.15^\circ \text{ F}$.
 - d. Sensor Probes: Aluminum alloy tube with type 304 stainless steel mounting brackets.
 - 1) Stations exposed to laboratory exhaust airstreams shall utilize type 316 stainless steel sensor mount tubing with Kynar thermistor brackets.
 - e. Signal Output: Analog (4-20mA, 0-5VDC or 0-10VDC) for airflow and temperature.

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- 1) Humidity Sensing Option: Analog (4-20mA, 0-5VDC or 0-10VDC) output for enthalpy or dewpoint. Sensor shall be a ruggedized capacitive polymer relative humidity sensor, with a minimum accuracy of +/-2% RH in a range of 20 to 80 % RH, and +/- 3.5% RH elsewhere. Long term drift shall not exceed 0.5% RH/year. Transmitter shall include calculated measurements for enthalpy and dew point using measured RH%, velocity-weighted temperature and on-board barometric pressure sensor. If the airflow station does NOT offer humidity sensing, the DDC system sub-contractor shall provide a separate humidity sensor, calculations, and barometric pressure compensation as specified above.
 - f. BAS Interface: BACnet IP or MS/TP communication interface.
 - g. Transmitter or User Interface: LCD display of temperature, velocity, and actual cfm. Enclosure shall be NEMA 1, where located indoors or 4X, with weatherproof cable connections, where located outdoors. [Install transmitter or interface remotely from the airflow station outside the duct or plenum.
 - h. Manufacturer's Warranty: 3 years.
 - i. Acceptable Manufacturer[s]: Subject to requirements, provide products by **[one of]**the following:
 - 1) Ebtron 'Advantage 4 Gold GTx116' Series
 - 2) Air Monitor Corporation 'ELECTRA-flo G5' Series
 - 3) Ruskin 'TDP05k' Series
37. Fan Inlet Airflow Measuring Stations: Thermal dispersion type, as generally described above for ductwork and plenum mounted stations, and manufactured by Ebtron ('Advantage IV Gold GTx108' series), Air Monitor Corp., or Ruskin, but with a $\pm 3\%$ of reading accuracy in a calibrated velocity range of 0 to 10,000 feet per minute air velocity. Provide 'face-mounted' type thermal dispersion stations (not 'throat-mounted'). Face type mounting shall utilize no mechanical fastening in the fan inlet throat or on the curved surface of the inlet bell, so as to preserve the performance-of the fan, however provide offset brackets to mount the sensors themselves further back in the fan throat. For fan arrays with fan staging control, provide a separate transmitter for each fan inlet station.
- a. At the Owner's option, a piezo ring fan inlet station may be used on fan inlets in lieu of the above specified thermal dispersion station. The airflow station itself (probes, tubing, etc.) shall be furnished by the equipment or fan manufacturer, with the station K-factor determined from the as-installed condition and field

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calibration. Stations furnished by parties other than the fan manufacturer are unacceptable.

- 1) The pressure transducer shall be provided by the HCS sub-contractor under this Section.
 - 2) The station shall be accurate within +/- 5% of reading at the design airflow rate, and throughout a 5 to 1 turndown range.
 - 3) No less than four (4) low pressure taps shall be provided for each fan inlet, with the average forming the low pressure signal to the transmitter or transducer. A single high pressure tap per fan inlet is acceptable.
 - 4) Station shall be constructed of nylon or copper tubing connected to aluminum or stainless steel pressure probes.
 - 5) Transmitter: A transmitter with integral pressure transducer shall be provided. For fan arrays, provide a dedicated transmitter for each fan inlet station.
 - a) The transmitter shall be a dead-ended type, and shall maintain a linear output signal through a range of 10 to 1 velocity turndown.
 - b) The transmitter shall be available in multiple natural spans covering the range of 0.05 IN w.c. to 25.0 IN w.c. with an accuracy of 0.1% of natural span. Transmitter shall be an Air Monitor 'VELTRON-II', or approved equal.
 - c) The differential pressure transducers shall be selected so that the usable full scale of the device shall be no greater than 90% of the natural span.
38. Fan Inlet Airflow Measuring Stations: Piezo ring type. The airflow station itself (probes, tubing, etc.) shall be furnished by the equipment or fan manufacturer, with the station K-factor determined from the as-installed condition and field calibration. Stations furnished by parties other than the fan manufacturer are unacceptable.
- a. The pressure transducer shall be provided by the HCS sub-contractor under this Section.
 - b. The station shall be accurate within +/- 5% of reading at the design airflow rate, and throughout a 5 to 1 turndown range.
 - c. No less than four (4) low pressure taps shall be provided for each fan inlet, with the average forming the low pressure signal to the transmitter or transducer. A single high pressure tap per fan inlet is acceptable.

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- d. Station shall be constructed of nylon or copper tubing connected to aluminum or stainless steel pressure probes.
 - e. Transmitter: A transmitter with integral pressure transducer shall be provided by the airflow station manufacturer. For fan arrays, provide a dedicated transmitter for each fan inlet station.
 - 1) The transmitter shall be a dead-ended type, and shall maintain a linear output signal through a range of 10 to 1 velocity turndown.
 - 2) The transmitter shall be available in multiple natural spans covering the range of 0.05 IN w.c. to 25.0 IN w.c. with an accuracy of 0.1% of natural span. Transmitter shall be an Air Monitor 'VELTRON-II', or approved equal.
 - 3) The differential pressure transducers shall be selected so that the usable full scale of the device shall be no greater than 90% of the natural span.
39. Carbon Dioxide (CO₂) Sensors: Non-dispersive infrared (NDIR) type, with temperature compensation. Wall-mounted devices shall have an LCD display of current sensed concentration.
- a. Materials: Molded plastic enclosure.
 - b. Mounting: Duct or wall.
 - c. Range: 0 to 2000 ppm.
 - d. Accuracy: +/- 50 ppm.
 - e. Repeatability: +/- 20 ppm.
 - f. Drift Stability: Less than 5% of full scale or max +/- 75 ppm over 3 years.
 - 1) Automatic background calibration.
 - g. Response time: Less than 2 minutes.
 - h. Barometric Drift or Compensation: Max. 1.5% change in reading per 0.15 psig deviation from 14.5 psig.
 - i. Protection: 175psi, -40°F to 140°F
 - j. Output: 0-10 VDC or 4-20mA
 - k. Warranty Period: 3 years.
 - l. Maximum Manufacturer's Recommended Calibration Interval: 3 years.

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- m. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) BAPI
 - 2) Honeywell
 - 3) Johnson Controls
 - 4) Siemens
 - 5) Vaisala
 - n. Calibration Kit: Provide a calibration kit that provides all required materials to enable the Owner to self-perform calibration of CO2 sensors. The kit shall include calibration gases at two levels of concentration (single point at 450 ppm, and span gas at 1,200 ppm), gas regulators, carrying case, flexible tubing and gas shroud (funnel), and instructions.
 - 1) Include enough calibration gases to perform at least 2 calibrations for each CO2 sensor provided on this project.
40. Occupancy Sensors: Provide occupancy sensor package in spaces identified in the Sequence of Operation or on the Drawings for control inputs into the DDC system. The intention of this project design is for the DDC system to have occupancy sensing that is coordinated and uses any available occupancy sensors used for lighting control. The sensors and all related wiring work is Division 23 work.
- a. Type: UL listed, ceiling mount, passive infrared (PIR) heat change sensing technology. PIR technology shall utilize a temperature compensated, dual element pyro-electric sensor and a multi-element extended range Fresnel lens.
 - a. Sensor shall be mounted to the ceiling with a flat, unobtrusive appearance and provide 360 degrees of coverage, minimum detection radius of 22 feet. The sensor shall have an LED indicator to verify detection within the area to be controlled.
 - b. Sensors shall have an adjustable time delay of 30 seconds to 30 minutes, and adjustable sensitivity and manual override features, all set by DIP switch.
 - c. Sensors shall feature a walk-through mode, where lights turn off 3 minutes after the area is initially occupied if no motion is detected after the first 30 seconds.
 - d. Outputs: The sensor shall have a single-pole, double throw internal isolated relay with normally open, normally closed and common outputs, rated at 1A at 24VDC/VAC.
 - e. Power Input: 37mA at 12VDC or 24VAC/DC.

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- f. Acceptable Product: WattStopper Model 'CI-24' series for ceiling applications and WattStopper Model 'CX-100' series for wall-mounted applications, or approved equal by Sensor Switch Inc.
41. Single-Point Water Leak Sensors: Water leak sensor utilizing a single set of gold plated sensing probes on the bottom of the device itself. The height of the probes above the monitored surface shall be adjustable between 0.0 and 0.5 inches.
- a. Output: Output: Two (2) Form C - 24V contacts rated for 3A each, each field configurable for NC or NO.
 - b. Acceptable Product: Vertiv or Liebert "Liqui-tect 410", or approved equal.
42. Cable-Type Water Leak Sensors: Water leak sensor utilizing a cable-type sensor up to 100 feet long. Detection of water along any portion of the cable shall trigger the device. Outputs shall be housed in a metal enclosure with a hinged top door providing access to the internal circuit board for wiring termination and configuration of DIP switches. The device shall include an adjustable alarm time delay.
- a. Output: Two (2) Form C - 24V contacts rated for 3A each, each field configurable for NC or NO.
 - b. Local Indication: LEDs to indicate fault condition.
 - c. Accessories: Cable hold-down clips and NEMA 4X enclosure to house sensor electronics.
 - d. Acceptable Product: Vertiv or Liebert "Liqui-tect 460" combined with "LT500Y" sensing cable, or approved equals.
43. Water Level Switches: Float type, with a float arm hinge design that limits vertical movement to prevent sticking. Float shall be replaceable.
- a. Level Actuation and De-Actuation: 0.75-inch deadband.
 - b. Body Pressure Limit: 1000 psi
 - c. Float Pressure Limit: 150 psig.
 - d. Temperature Range: -4 to 275 deg. F.
 - e. Switch Type: SPDT snap switch, with 10 A at 125/250-VAC electrical rating.
 - f. Float and Rod: Type 316 stainless steel.
 - g. Body: Brass or Type 316 stainless steel.
 - h. Magnetic Keeper: Type 430 or 316 stainless steel.

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- i. Enclosure: NEMA 250, Type 4.
44. Liquid Level Sensors and Transmitters: Ultrasonic, non-contact measurement principle, with narrow (2" or less) beam diameter and temperature compensation.
- a. Temperature Limit: 140 deg. F.
 - b. Pressure Limit: 30 psig.
 - c. Measuring Depth: To suit application.
 - d. Accuracy: 0.2 inch or +/- 0.2% of sensor range, whichever is greater.
 - e. Repeatability: < 0.12 inch
 - f. Resolution: < 0.12 inch
 - g. Output: 4-20 mA or 0-10VDC, reversible.
 - h. Enclosure: Polypropylene, PVDF, or Polycarbonate, NEMA 250, Type 6 (IP67), 6P (IP68), or 4X (IP66).
 - i. Accessories: Provide PVC or stainless steel stilling chamber for cooling tower applications.
 - j. Acceptable Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1) Dwyer Instruments
 - 2) Flowline
 - 3) Omega Engineering
 - 4) Drexelbrook
45. Slab Temperature Sensors: Hermetically sealed, moisture proof 10K ohm NTC thermistor type, with a thermally conductive coating. Wire length shall be as required to place the sensor at any location in the heated slab.
- a. Range: 4 to 176 deg. F.
 - b. Accuracy: +/- 0.5 deg. F.
46. Snow Melt Control Sensors: 24-V, microprocessor-based, with outputs for snow detection and slab temperature. Detector shall be corrosion-proof and waterproof enclosure suitable for outdoor mounting, with the top surface flush with the surrounding pavement. Sensor housing and mounting socket shall be constructed of silicon brass or stainless steel.

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- 47. Snow/ Rain Detector: Thermistor-heated conductivity grid type precipitation sensor.
 - a. Enclosure: NEMA 3R
 - b. Ambient Temperature Rating: - 40 deg. F. to 185 deg. F.
 - c. Mounting: Double gag box, wall or conduit.
 - d. Power Requirement: 15VA max. at 22-28 VAC
 - e. Output: Form C Contacts
 - f. Special Features:
 - 1) Adjustable sensitivity control (3 seconds to 4 minutes)
 - 2) Adjustable delay off cycle (30 minutes to 6 hours)
 - 3) Internal temperature sensor and adjustable 'trigger' temperature control
 - g. Manufacturer: ASE 'DS-224' or approved equal.
- 48. Wind Speed and Direction Sensor: Ultrasonic principle type, in an aluminum or stainless steel housing. No moving parts are permitted.
 - a. Wind Speed Range: 0-134 mph.
 - b. Direction Range: 0-359 deg.
 - c. Ambient Temperature Tolerance Range: -31 deg. F. to +158 deg. F. Sensor shall be heated.
 - d. Ambient Relative Humidity Tolerance Range: 5% RH to 100% RH.
 - e. Speed and Direction Sensing Accuracy: +/- 2% at 26.8 mph.
 - f. Response: 0.25 seconds.
 - g. Housing: IP66, and impact resistant to UL 2218, Class 1.
 - h. Outputs: 0-5VDC or 4-20 mA for both speed and direction.
 - i. Accessory: Mounting bracket.
 - j. Manufacturer: Gill Instruments 'WindSonic M', or approved equal.
- 49. Window Monitoring Switches: Fully recessed for an entirely concealed installation when the window is closed. Normally open hermetically sealed reed switch contacts with sensitivity up to 1/2" separation. Provide both magnet and switch portions of the device.

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Switch shall include minimum 12" long wiring leads and shall be rated for minimum 0.5A at 100V. Coordinate the exact switch type and installation with the window supplier.

B. Relays:

1. Control Relays:

- a. Materials: Gold Flash.
- b. Rating: 10amps @ 120-277vAC.
- c. Mounting: Standard Electrical Box.
- d. Protection: NEMA 1 Housing.
- e. Output: SPDT, DPDT.
- f. Special: Provide LED for position indication. Provide with HOA switch, except when used in smoke control applications.

2. Remote Current Switch or Command Relay Combination:

- a. Mounting: Panel or Electrical Box
- b. Range: .5 to 16 Amps
- c. Trip Set-point: Adjustable
- d. Sensor Power: Induced
- e. Max. Operating Voltage: 250 VAC
- f. Frequency Range: 50/60 Hz.
- g. Humidity Range: 0 to 95% non-condensing
- h. Operating Temperature: -15° to 60°C
- i. Status Output: 1.0A @ 30 VAC/DC
- j. Switch shall have HOA switch to override and troubleshooting
- k. Switch shall include belt loss detection feature.
- l. Manufacturer: Hawkeye H548 series, or approved equal.

C. Controlled Output Devices:

- 1. Control Valves, General Requirements: All valve shall be tight closing, quiet in operation and be arranged to fail safe, in either a normally open or normally closed position in event of a power failure.

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- a. All modulating valves shall be fully proportioning.
 - b. Normal position shall be as indicated in the sequences of operation, points list, or on the Drawings.
 - c. All two-position valves shall have spring returns.
 - d. Valves sized 2" and larger shall have position indication.
2. Modulating, Pressure-Dependent, Two-Way and Three-Way Hydronic Characterized Bronze Ball Control Valves- 2 inches and smaller:
- a. Forged bronze, stainless steel ball and blowout proof stainless steel stem and EPDM O-rings with minimum 600 psi CWP (WOG) rating. Modulating valves shall contain glass filled ball insert capable of providing equal percentage flow. Valves shall have allowable media temperature of 20 deg. F to 250 deg. F. Brass body valves are not acceptable.
 - b. Leakage Rating:
 - 1) Valves 1" and smaller: FCI 70-2, Class III.
 - 2) Valves 1-1/4" to 2": FCI 70-2, Class IV.
 - c. Rangeability: Minimum 150 to 1.
 - d. Close Off Rating: Provide close-off pressure 10% higher than the maximum system pressure, or the following minimum, whichever is greater:
 - 1) 2-Way Valves: 100 psid.
 - 2) 3-Way Valves 70 psid.
 - 3) Issue RFI if maximum system pressure is not defined in construction documents.
 - e. Medium: Valves shall be used with hot water or cold water with up to 50% glycol.
 - f. Modulating Valve Flow Characteristics:
 - 1) 2-way valves serving heat exchange devices (e.g. coils, heat exchangers, etc.) shall have equal percentage characteristics by way of a shaped characterizing disc with a V-shaped opening. The characterizing disc shall be located on the inlet side of the ball and secured in place between the ball and seat. Discs secured by C-clips (i.e. 'circlips' or snap rings) will not be acceptable.

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- 2) 2-way hydronic bypass valves maintaining minimum system flowrates shall have linear flow characteristics.
 - 3) 3-way valves shall have an equal percentage characteristic through the control port, and a linear characteristic through the bypass port.
 - g. Subject to compliance with requirements, provide valves by one of the following manufacturers:
 - 1) Belimo
 - 2) Bray International
 - 3) Honeywell
 - 4) Johnson Controls Inc.
 - 5) Siemens
 - h. Refer to Part 3 this Section for sizing requirements.
3. Two-Position, Two-Way and Three-Way Hydronic Bronze Ball Control Valves- 2 inches and smaller:
 - a. Forged bronze, stainless steel ball and blowout proof stainless steel stem and EPDM O-rings with minimum 600 psi CWP (WOG) rating. Valves shall have allowable media temperature of 20 deg. F to 250 deg. F. Brass body valves are not acceptable.
 - b. Leakage Rating:
 - 1) Valves 1" and smaller: FCI 70-2, Class III.
 - 2) Valves 1-1/4" to 2": FCI 70-2, Class IV.
 - c. Close Off Rating: Provide close-off pressure 10% higher than the maximum system pressure, or the following minimum, whichever is greater:
 - 1) 2-Way Valves: 100 psid.
 - 2) 3-Way Valves 70 psid.
 - 3) Issue RFI if maximum system pressure is not defined in construction documents.
 - d. Medium: Valves shall be used with hot water or cold water with up to 50% glycol.

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- e. Subject to compliance with requirements, provide valves by one of the following manufacturers:
 - 1) Belimo
 - 2) Bray International
 - 3) Honeywell
 - 4) Johnson Controls Inc.
 - 5) Siemens
 - f. Refer to Part 3 this Section for sizing requirements.
 - 1) Xylem or Bell and Gossett
4. Pressure-Dependent Two-Way Hydronic Butterfly-Type Control Valves, sized 2.5 inches and larger, and Three-Way Valves sized 2.5 inches and larger:
- a. Butterfly valves shall be ASTM A126 cast-iron or ASTM A536 ductile-iron, with a lug-wafer body and rated at 150 psig except where otherwise noted. Extended neck design.
 - b. 3-Way Valves: Two (2) - two-way butterfly valves, independently actuated, with control signals arranged so that the valves work in opposition for mixing or blending action, as required.
 - c. Stem: Stainless steel with field replaceable EPDM sleeve and stem seals.
 - d. Disc: Stainless steel or elastomer-coated ductile iron.
 - e. Seat: EPDM.
 - f. Leakage Rating: ANSI or FCI 70-2 Class VI ('bubble tight' shutoff).
 - g. Rangeability: Minimum 10:1 for 30° to 70° stroke range.
 - h. Close Off Rating, whichever is larger:
 - 1) Chilled Water: Minimum 150 psi close off.
 - 2) Other than Chilled Water: Minimum 100 psi close off on 2-way valves and 70 psi on 3-way valves
 - 3) Issue RFI if maximum system pressure is not defined in construction documents.

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- i. Medium: Valves shall be used with hot water or cold water with up to 50% glycol, with temperatures up to 210 deg. F.
 - j. Subject to compliance with requirements, provide valves by one of the following manufacturers:
 - 1) Belimo
 - 2) Bray International
 - 3) Honeywell
 - 4) Johnson Controls Inc.
 - 5) Siemens
 - k. Refer to Part 3 this Section for sizing requirements.
5. Globe Control Valves - Steam, sizes 2" and smaller:
- a. Class 125 or 150, bronze body, stainless steel trim, rising stem, renewable composition disc, and screwed ends with back-seating capacity re-packable under pressure. Valves shall have stainless steel stems and allow for servicing including
 - b. Flow Characteristics: Equal percentage.
 - c. Internal Construction: Replaceable plugs and seats of stainless steel. Teflon packing. Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.
 - d. Leakage Rating: ANSI or FCI 70-2, Class IV.
 - e. Rangeability: Minimum 50 to 1.
 - f. Steam Rating: All components shall be suitable for up to 125 psig saturated steam (125 SWP).
 - g. Sizing: Refer to Part 3 this Section for sizing requirements.
 - h. Manufacturers: Subject to compliance with requirements, provide valves by one of the following manufacturers:
 - 1) Belimo
 - 2) Bray International
 - 3) Honeywell
 - 4) Johnson Controls Inc.

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- 5) Schneider Electric
 - 6) Siemens
6. Segmented V-Ball Control Valves - Steam, sizes 2" and larger:
- a. Construction: Carbon Steel Body. Stainless steel stem, hardened stainless steel V-notch ball, field replaceable reinforced Teflon seat, and maintenance free spring loaded Teflon packing. -20 to 400 deg. F. temperature range.
 - b. Flow Characteristic: Equal Percentage.
 - c. ASME B16.10 Face to Face Dimensions
 - d. Leakage Rating: ANSI or FCI 70-2 Class VI ('bubble tight' shutoff)
 - e. Rangeability: 300:1.
 - f. Rated for no less than 250 psig at 400 deg. F.
 - g. Refer to Part 3 this Section for sizing requirements.
 - h. Subject to compliance with requirements, provide segmented V-ball steam control valves by one of the following manufacturers:
 - 1) Belimo, "VB V-Ball" series.
 - 2) Bray Intl. or Flow-Tek, "V Control" series.
 - 3) DeZurik, "VPB" series.
 - 4) Fisher, "Vee-Ball" series.
 - 5) Trimteck, "OpVEE V-Notch" series
 - 6) Valve Solutions Inc. (VSI), Series "V".
7. Control Dampers:
- a. The DDC Contractor shall furnish all automatic control dampers not specified to be supplied integral to the HVAC equipment. These field-applied dampers shall be installed by the Division 23 Contractor.
 - b. Dampers shall be supplied with shaft or control rod extended to accommodate the specified operator. Only one control shaft per damper section. Only one actuator per damper shaft. Provide multiple damper sections mulled together when required to meet application requirements.
 - c. Damper actuators shall not be installed inside ducts unless specifically indicated on the Drawings, or approved by the Engineer.

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- d. Jackshaft Assemblies: Provide jackshafts for actuation, in lieu of using the damper's integral control rod, where required by the application, as recommended by the damper manufacturer. Jackshafts shall be TAMCO 'Horizontal Jackshaft' or 'Vertical Jackshaft', or approved equal.
- 1) Frame mounting brackets (i.e. bridge and side brackets) for the jackshaft shall be mill finish extruded aluminum, minimum 0.125-inch thickness.
 - 2) Bearings: Minimum 1-inch inner diameter, maintenance-free, high-strength, abrasion and impact resistant thermoplastic polyamide. Sleeve bearings are not acceptable.
 - 3) Bearing Housings: Mill finish extruded aluminum, bolted directly to the frame mounting bracket.
 - 4) Blade Clips: Mill finish extruded aluminum and mounted directly to the drive blade. Formed blade clips are not acceptable.
 - 5) Jackshaft: Minimum 1-inch diameter extruded aluminum tubing. No more than one jackshaft per damper section.
 - 6) Crank arms, locking collars, and link bars shall be mill finish extruded aluminum. All non-aluminum parts are to be zinc-plated or galvanized steel.
 - 7) Jackshaft rotation shall be 90 degrees and shall allow for direct mounting of actuators with no additional connectors or drive rods required.
 - 8) Jackshafts shall be mounted directly over the drive blade in order to minimize length of the link bars.
 - 9) Jackshaft linkage shall have fixed arms and bearings located at pivot points. Swivels are not acceptable.
- e. Shape Applications:
- 1) For dampers shown on rectangular ducts, provide multi-bladed rectangular dampers matching the duct size. Damper frames shall have integral flanges for duct connections on each side (i.e. in-duct frame types are not acceptable). For dampers with heights less than 12", a single blade damper may be provided.
 - 2) For dampers shown on round ducts, unless the damper size or shape is explicitly identified, the Contractor shall provide a round, single blade, butterfly type damper.
- f. Material Applications:

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- 1) Provide aluminum or galvanized steel damper construction (blades, frames, axles, and linkages) in galvanized duct systems.
 - 2) Provide aluminum dampers (aluminum blades, frames, axles, and linkages) in aluminum duct systems.
 - 3) Provide Type 304 stainless steel dampers (stainless steel blades, frames, axles, and linkages) in stainless steel duct systems (e.g. dishwasher exhaust).
 - 4) Refer to Division 23 Section "Ductwork" for duct construction materials specified.
 - 5) Provide insulated dampers where indicated on the Drawings.
- g. Rectangular Control Damper Blade Configuration:
- 1) All modulating or proportional dampers shall be opposed blade type.
 - a) Exception: Outdoor-air and return-air dampers as part of a mixed air arrangement shall be parallel blade.
 - 2) Two-position dampers may be of the opposed or parallel blade type (Contractor's option).
- h. Rectangular Control Dampers, Standard Construction:
- 1) Provide Standard Construction dampers where installed in galvanized steel ductwork, unless otherwise indicated.
 - 2) Where indicated for installation in aluminum ductwork, provide damper with aluminum frames, blades, and axles.
 - 3) Frames: Minimum 16 gauge galvanized steel structural hat channel with tabbed/reinforced corners. Extruded aluminum frames, minimum .080" thick, are also acceptable.
 - 4) Blades: 14 gauge equivalent thickness galvanized steel. Blades shall be roll-formed airfoil type. Extruded 6000-series aluminum airfoil blades, minimum .060" thick, are also acceptable.
 - 5) Blade Edge Seals: EPDM or extruded silicone suitable for -40°F to +212°F, mechanically locked into the blade edge. Adhesive or clip-on type seals are unacceptable.
 - 6) Jamb seals: Flexible stainless steel, compression type to prevent leakage between blade end and damper frame. Blade end overlapping frame is

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unacceptable. EPDM or extruded silicone jamb seals are also acceptable in lieu of stainless steel.

- 7) Bearings: Corrosion resistant, permanently lubricated stainless steel sleeve or bronze oilite type turning in an extruded hole in the damper frame.
- 8) Axles: Minimum 7/16" cadmium plated steel or extruded aluminum. Hexagonal shape positively locked into the damper blade. Linkage shall be concealed out of air-stream, within the damper frame to reduce pressure drop and noise. Linkage bearings shall be stainless steel sleeve or bronze oilite.
- 9) Leakage Performance: Damper submittal shall include leakage, maximum airflow and maximum pressure ratings based on AMCA Publication 500. Dampers shall bear the AMCA 511 label for air leakage.
 - a) Damper shall leak less than 3 cfm/sq. ft. at 1" of static pressure as per AMCA 500 (Class 1A damper), up to 60" blade width.
- 10) Pressure Drop Performance: A 36" x 36" sized damper shall have no more than .06 inches w.g. static pressure drop at 2,000 fpm face velocity, fully open.
- 11) Pressure and Velocity Ratings: Damper construction shall be suitable for up to 7" w.g. static pressure differential and 3,000 fpm face velocity in blade lengths up to 36".

i. Rectangular Insulated Control Damper Construction:

- 1) Dampers shall be as described above for Standard Construction, except for the following:
 - a) Blades, frame, and axles shall be aluminum or stainless steel, or a combination thereof (i.e. galvanized steel is not acceptable).
 - b) The internal volume of the blades shall be filled with high density expanded foam insulation, and the blades shall have an R-value of no less than 2.3.
 - c) Frame shall be thermally broken with polyurethane resin pockets and thermal cuts. If the frame is not thermally broken, damper will still be acceptable if the damper has an AMCA Std. 500-D Thermal Efficiency Ratio of no less than 340%.

j. Rectangular Stainless Steel Control Damper Construction:

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- 1) Dampers shall be as described above for Standard Construction, except for the following:
 - a) Blades may be of the single thickness, 3-V type, and minimum 16 gauge.
 - b) Blades, axles, and frame shall be constructed of Type 304 stainless steel.
 - c) Damper may be AMCA 500 licensed as a Class 1 damper (in lieu of Class 1A).
 - d) Pressure and Velocity Ratings: Damper construction shall be suitable for up to 4" w.g. static pressure and 2,500 fpm face velocity.
- k. Round Control Damper Construction: Single blade, butterfly type with actuator mounting bracket. Minimum 20-gauge frame, and minimum 16 gauge blade (with higher gauges as required to meet pressure and velocity requirements). Bronze oilite bearings. Closed cell neoprene or EPDM damper frame or damper bade edge seal. Suitable for up to 4" w.g. static pressure and 3,000 fpm face velocity. AMCA licensed as a Class 1 damper.
 - 1) Galvanized: Galvanized steel blade and frame. Cadmium plated steel shaft and control rod.
 - 2) Stainless Steel: Type 304 stainless steel blade, frame, shaft, and control rod.
- l. Subject to compliance with requirements, provide one of the following products:
 - 1) Rectangular, Standard Construction:
 - a) Ruskin 'CD50' (aluminum) or 'CD60' (galv. steel)
 - b) TAMCO '1500 Series'
 - c) Arrow 'AFD-20'
 - d) Greenheck 'VCD-33' (galv. steel) or 'VCD-40' (aluminum)
 - e) Johnson Controls 'VD-1330' (aluminum) or 'VD-1630' (galv. steel)
 - f) Pottorff 'CD-51/52' (aluminum) or 'CD-45/46' (galv. Steel)
 - 2) Rectangular, Insulated:
 - a) Ruskin ' CDTI-50'
 - b) TAMCO '9000 BF'

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- c) Greenheck 'ICD-45'
 - d) Pottorff 'TICD-52-BF'
 - e) Arrow 'AFDTI-25'
 - 3) Rectangular, Stainless Steel:
 - a) Greenheck 'VCD-33' (with Type 304 stainless steel option)
 - b) Approved Equal.
 - 4) Round, Galvanized:
 - a) Arrow 'Type 70'
 - b) Ruskin 'CDRS25'
 - c) Johnson Controls 'RV-1600' and 'RL-1000'
 - 5) Round, Stainless Steel:
 - a) Arrow 'Type 80'.
 - b) Ruskin 'CDRS25' (with Type 304 stainless steel construction option)
 - c) Johnson Controls 'RV-1600' and 'RL-1000' (with Type 304 stainless steel construction option)
8. Electric Actuators: The actuators shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Magnetic clutch to deactivate the actuator at the end of rotation are not acceptable.
- a. For power-failure and safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable. All spring return actuators shall be capable of either clockwise or counterclockwise spring return operation by simply changing the mounting orientation.
 - b. Actuators shall be designed for a minimum of 65,000 full stroke cycles at the actuator's rated torque and shall have a 2-year manufacturer's warranty, starting from the date of Substantial Completion.
 - c. Actuators shall be UL listed.

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- d. Electric Damper Actuators: Provide one actuator per damper section or damper shaft. Multiple actuators installed on a given shaft (i.e. "tandem mounting") is not acceptable.
- 1) Rating: NEMA 1 or 2 enclosure where located indoors. NEMA 4X where located outdoors.
 - 2) Mounting: Direct mount on the associated damper shaft.
 - 3) Location: Outside the ductwork.
 - 4) Minimum actuator resolution: 100:1
 - 5) Maximum actuator hysteresis: 2%
 - 6) Stroke Time: 90 seconds end to end full stroke, 15 seconds return to normal for spring return.
 - 7) Protection: Electronic stall protection.
 - 8) Control Input: 0-10 VDC or 0-20mA DC.
 - 9) Power: Nominal 24 VAC.
 - 10) Torque: Size for minimum 150% of required duty.
 - 11) Duty Cycle: rated for 65,000 cycles.
 - 12) Special: Output position feedback, manual override, field selectable rotational/spring return direction, field adjustable zero and span.
 - 13) Warranty: Two years, unconditional.
 - 14) Provide built-in auxiliary switch for interfacing or signaling.
 - a) This switch shall not be utilized to provide position indication if an independent end switch device is required elsewhere by this Specification, or is indicated in the Sequences of Operation or on the Drawings.
- e. Electric Valve Actuators: Provide one actuator per valve. Multiple actuators installed on a given shaft (i.e. "tandem mounting") is not acceptable.
- 1) Rating: NEMA 1 or 2 Enclosure where located indoors. NEMA 4X where located outdoors.
 - 2) Mounting: Direct mount only.

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- a) Linkages, gearboxes, and rack/pinion arrangements are NOT acceptable, except on steam service globe valves where they are permitted.
 - b) Three-way butterfly control valve arrangements shall utilize two independent actuators (one per valve) controlled to a common pilot signal.
 - 3) Minimum actuator resolution: 100:1
 - 4) Maximum actuator hysteresis: 2%
 - 5) Stroke Time: 90 seconds end to end full stroke, 15 seconds return to normal for spring return.
 - 6) Control Input: 0-10 VDC or 0-20mA DC.
 - 7) Power: Nominal 24 VAC.
 - 8) Protection: Stall protection.
 - 9) Torque: Size for minimum 150% of required duty.
 - 10) Duty Cycle: rated for 65,000 cycles.
 - 11) Warranty: Two years, unconditional.
 - 12) Special: Output position feedback, manual override, field selectable direction, field adjustable zero and span.
 - a) For spring return (all valves except those 6" and larger), provide field selectable spring return direction.
 - b) Provide built-in auxiliary switch for interfacing or signaling.
- f. Acceptable Manufacturers: Subject to compliance with requirements, provide actuators by one of the following manufacturers:
- 1) Belimo
 - 2) Bray International
 - 3) Honeywell
 - 4) Johnson Controls Inc.
 - 5) Schneider Electric
 - 6) Siemens

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- 7) IMI-TA
 9. I/P (Current to Pneumatic) and E/P (Voltage to Pneumatic) Transducers:
 - a. Transducers shall meet the following specifications:
 - 1) Supply pressure: 25 psig \pm 2 psig
 - 2) Signal: 4-20 mA or 0-10 V
 - 3) Output pressure: 3-15 psig
 - 4) Linearity: +1.0 percent of span at 25 psig supply
 - 5) Flow Rate, Midrange: 4.5 SCFM at 25 psig
 - 6) Air Consumption, Midrange: 0.1 SCFM
 - 7) Supply Pressure sensitivity, Midrange: +1 percent of span per psig
 - 8) Minimum Over-pressurization without Damage: 30 psig
 - b. Each transducer output signal shall be provided with a minimum 1-inch diameter pressure gauge or LCD display.
 - c. Outputs from transducers shall be used to control valves, control dampers, or to reset pneumatic control setpoints.
 10. E/P Valves (Relays): EP valves shall have three port operation: common, normally open, and normally closed. EP valves shall have an outer cast aluminum body with internal parts constructed of brass, bronze, or stainless steel. The air connection shall be a 3/8 inch NPT threaded connections. EP valves shall be rated for 50 psig when used in control system operation at 25 psig or less, or rated at 150 psig when used in control system operation from 25 to 100 psig. EP coils shall be equipped with transient suppression to limit transients to 150 percent of rated voltage. EP valve operation shall be rated for a minimum of 220°F.
- D. Miscellaneous Accessories:
1. Weather- and Sun-Shields: Provide for temperature sensors located outdoors shall prevent the sun from directly striking the sensor. The weathershield shall be provided with adequate ventilation so that the sensing element responds to the ambient conditions of the surroundings. The weathershield shall prevent rain from directly striking or dripping onto the sensor. Weathershields installed near or in outside air intake ducts shall be installed such that normal outside airflow does not cause rainwater to strike the sensor. Weathershields shall be constructed of unpainted aluminum or white PVC.

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- a. The shield shall be a BAPI 'Weather Shade' or approved equal.
2. Clear Anti-Tamper Thermostat Guard: Clear plastic hinged cover, with vented base and integral key lock. Guard shall be Honeywell 'TG5xxx' series, or approved equal.
3. Opaque Anti-Tamper Thermostat Guard: Painted off-white steel cover with vented plastic base and integral key lock. Guard shall be Honeywell 'TG5xxx' series, or approved equal.
4. Protective Thermostat Guard: Zinc-plated steel wire guard to prevent thermostat damage from impacts, but with an open face design to permit thermostat access and adjustment. Wire shall be no less than #6 gauge (0.20" diameter), and shall be [epoxy lacquer clear coated. Guard shall be American Wire Guards 'Gage Style', or approved equal.
5. Protective and Anti-Tamper Thermostat Guard: White epoxy coated 16-gauge perforated steel enclosure with hinged cover and integral key lock. Guard shall be Chase Security Systems 'PTG' series, or approved equal.

2.13 COMBINATION BACKDRAFT DAMPERS AND AIRFLOW MEASURING STATIONS

- A. General: Factory furnished as a complete assembly, combining a backdraft damper and thermal dispersion type airflow measuring station mounted in a common aluminum sleeve. Overall assembly length in the direction of airflow shall not exceed 9", and the required upstream clearance shall not exceed 7". The position of the velocity sensor probes relative to the damper blades throughout their full range of movement shall be carefully determined to ensure airflow measurement accuracy. The assembly shall be a complete factory engineered and designed system, and field-pairing of stations and backdraft dampers by the Contractor are not acceptable.
 1. Provide a rectangular bellmouth or radius flare inlet.
- B. Backdraft Dampers: 6063-T6 extruded aluminum hat channel frame, .080 inches thick. Aluminum blades (6063-T6 AL) shall be no less than 0.80" thick, with mechanically fastened extruded silicone rubber blade edge seals and minimum 7/16" diameter aluminum axles pin-locked to frame and positively locked to blades. Aluminum and zinc-plated steel linkage hardware shall installed in the side of the frame, outside of the airstream. Damper assembly shall be provided with an adjustable counter-balance device adjusted to assist opening. Counterweight shall permit the start of opening with as little as 0.01" w.g. differential pressure.
 - a. Construction shall provide up to 9.5" w.g. differential pressure and 3,500 feet per minute velocity with 24" long blades. Provide multiple dampers and airflow station assemblies mulled together to form backdraft dampers with blade widths accommodating the scheduled total static pressure and airflow or velocity ratings of the associated fans.

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- b. Static pressure drop at 2,000 fpm face velocity shall not exceed 0.28" w.g. when tested in accordance with AMCA 500D in the 24"x24" size.
 - c. Dampers shall not have a leakage rate exceeding 10 cfm/sq.ft. at 1.0" w.g. differential pressure when tested in accordance with AMCA 500D in the 24"x24" size.
- C. Airflow Measuring Stations: Multiport, self-averaging thermal dispersion tube station using sealed thermistors. Sensor density shall be no less than that required to produce the sensing accuracy specified below for the installed conditions of this Project. Each thermistor pair location shall independently measure velocity of the airstream. Differential pressure based stations are not acceptable. For fan arrays with fan staging control, provide a separate transmitter for each fan inlet station.
 - a. Power Requirement: 24 VAC.
 - b. Calibrated Velocity Range: 0 to 5000 fpm.
 - c. Sensing Point Accuracy:
 - 1) Flow: $\pm 2\%$ of reading, between 0 and 10,000 feet per minute air velocity, with a NIST traceable certificate.
 - 2) Temperature: $\pm 0.15^\circ \text{ F}$.
 - d. As-Installed Airflow Accuracy: $\pm 3\%$ of reading.
 - e. Sensor Probes: Zinc-plated steel rods with type 304 stainless steel mounting brackets, with two thermistor pairs per probe.
 - f. Signal Output: Analog (4-20mA, 0-5VDC or 0-10VDC) for airflow and temperature.
 - g. BAS Interface: BACnet IP or MS/TP communication interface.
 - h. Transmitter or User Interface: LCD display of temperature, velocity, and actual cfm. Enclosure shall be NEMA 1 if indoors, or 4X if outdoors, with weatherproof cable connections.
 - i. Manufacturer's Warranty: 3 years.
- D. Acceptable Manufacturer: Subject to requirements, provide products by the following:
 - 1. Ebtron 'FAN-IQ' Series, consisting of a TAMCO '7600 CWA' damper and an Ebtron 'Advantage 4 Gold' series fan inlet type airflow measuring station. No Substitutions

2.14 DEMAND BASED KITCHEN EXHAUST HOOD CONTROL SYSTEM

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A. General:

1. Provide a demand-based kitchen hood control system (KHCS) to automatically control the speed of each variable speed kitchen hood exhaust fan and associated make up air system supply fan to ensure acceptable hood performance with the minimum of exhaust airflow (i.e. demand based control). The system shall include the following minimum components: system controller, hood controller, hood control interface or touchpad, temperature sensors, optic sensors, variable frequency drives and cables.
2. The KHCS shall include controls that sense temperature of the exhaust air in the hood and vary the fan speed to maintain safe and effective kitchen exhaust per current ASHRAE / ANSI / IES Standard 90.1. The temperature sensors shall be canopy mounted. The KHCS shall additionally monitor cooking activity under the kitchen hood via auto-calibrated infrared optic sensors consisting of an emitter and receiver mounted on either side of the hood canopy, if provided by manufacturer. Optic sensors, with dedicated air purge units (APUs), shall immediately increase fan speeds to 100% upon detection of smoke or effluent in the hood canopy with a response time of 0.2 seconds. Upon evacuation of smoke or effluent the fans shall modulate according to exhaust temperature for optimal energy savings.
3. The system shall be capable of operating exhaust fan motors at minimum speeds of 50%. The KHCS shall actively modulate makeup airflow according to exhaust load to maintain the desired space airflow balance.
4. The KHCS supplier shall function as a supplier/subcontractor to the DDC system subcontractor.
5. The hood controller and control interface or keypad shall be mounted on the wall adjacent to fire suppression and alarm equipment.
6. The VFD shall be mounted where shown on the HVAC Drawings.
7. The system shall be UL Listed, and conform to all applicable codes and standards including the current edition of NFPA 96, the current edition of the International Mechanical Code, and shall be NSF and CE labeled.
8. Special Warranty: The manufacturer shall warrant the system to be free of defects in material and workmanship for a period of three (3) years from the first date of beneficial use by the Owner following final acceptance. Warranty shall include labor and either repair or replacement of this equipment.

B. Acceptable Manufacturers: Provide systems by one of the following:

1. Melink Corp. - "Intelli-Hood"
2. Greenheck "GKC-DCV"

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3. Gaylord "AirVantage"
 4. CaptiveAire "DCV"
- C. System Components: At the minimum, the following components shall be provided:
1. System Controller(s): Sends an analog exhaust airflow command for each hood and fan combination to the associated variable frequency drive. The quantity of processors provided shall be as required to independently control all of the variable speed hood exhaust fans. The KHCS shall have a BACnet TCP/IP or BACnet MS/TP interface to the DDC system.
 2. Hood Control Interface or Keypad: Controls fans associated with the hood from active mode (i.e. "ON") to standby mode (i.e. "OFF"). Provide one keypad per fan where shown on the Drawings. LCD display with keypad or touchscreen for adjustment and control over fans and hood lighting.
 3. Temperature Sensor(s): Monitor exhaust air temperature at duct (one sensor per exhaust duct). Sensor(s) shall be three-wire resistive temperature device (RTD) encased in a stainless steel tube. Housings and fittings shall be UL-listed and grease-tight. Temperature Rating: 32° to 1000°F
 4. Optic Sensor(s): Monitor smoke load inside hood (minimum one sensor per 8 ft. long section of hood). Optic sensors shall consist of conformal coated emitter and receiver boards housed in stainless steel enclosures on opposite ends of the kitchen hood interior. Infrared sensors capable of detecting effluent in the air at any point along the length of the beam with a response time of 0.2 seconds. Sensors shall be capable of spanning 3 to 40 feet of kitchen hood interior with automatic gain adjustment. Optic sensors shall auto-calibrate every day at start up and/or every 24 hours. Sensors shall be wired to system controller with liquid-tight connectors at sensor board via the Air Purge Unit (APU). Optic Sensor Temperature Rating: 32° to 185°F
 - a. Air Purge Units (APUs) shall consist of a 12VDC blower and interface PCB inside an 18 gauge galvanized steel enclosure shall be installed to reduce the accumulation of contamination on the optic sensor lenses and reduces heat buildup inside the optic sensor enclosure. The APUs shall physically connect to the optic sensor enclosure via stainless steel conduit pipe. The blower fan bearings shall be permanently lubricated.
 5. Cables: Links system controller to interface keypad, sensors, and VFDs. Lengths shall be field measured.
 6. VFDs for exhaust fans shall be provided by Division 23 in accordance with Section 236700.
- D. Division of Responsibilities:

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1. The KHCS shall either be field-mounted on the hood or factory-mounted on the hood. Factory installation of the KHCS at the hood manufacturer's facility is permitted but NOT required, however all KHCS requirements shall be thoroughly coordinated with the hood supplier.
2. System components shall be field-wired by the HCS Contractor with plug-n-play cables provided by the KHCS supplier.
3. The KHCS supplier shall program the system based on the application.
4. The Division 23 Contractor shall power the system processor with an input of 115/1 VAC from a dedicated 20A circuit.
5. HCS Contractor shall install the plug-n-play cables from the system controller to each hood touchpad and sensors.
6. HCS Contractor shall start-up the system by pressing the fan switch on keypad to verify the hood fans go to minimum speed. Correct fan rotation if necessary.
7. HCS Contractor shall coordinate an Ethernet connection of the KHCS to an internet gateway such that KHCS controller can connect to the KHCS manufacturer's server.
8. HCS Contractor shall provide all communications wiring between the system controller and BACNet interface to the building DDC system.
9. HCS Contractor shall provide all required shutdown interlock wiring, relays, etc. to de-energize the hood exhaust and make up air system(s) whenever the associated hood's fire protection system is in alarm.
10. HCS Contractor shall provide the interlock wiring from the control system to the motorized gas valve that prevents use of the cooking appliances until the exhaust fan is confirmed to be energized.
11. HCS Contractor shall wire the hood lights through the system controller.
12. The KHCS manufacturer's representative shall be on-site at the time of start-up, during commissioning of the system, and during trouble shooting.
13. The testing and balancing (TAB) agent shall air balance the system exhaust fans for design flow with the system controller commanding the exhaust to 100%.

E. Performance and Operational Requirements:

1. Exhaust fans shall operate at a preset minimum speed during idle periods. Then the operator turns on the cooking appliances and the resulting heat load causes the fan speeds to increase proportionately with the exhaust air temperature. Upon the detection of smoke/vapors inside the hood, the fans shall ramp up to 100% speed to ensure proper capture performance (and compliance with national and local codes).

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2. The system shall automatically turn on the exhaust as the duct temperature rises above 90F degrees. Similarly, the system shall automatically turn off as the temperature drops below 75F.
 3. In the event of any problem, the operator shall be able to press a bypass switch on the keypad to operate the fans at 100% speed. This bypass feature shall have a programmable timer to ensure the energy-saving mode is resumed after an adjustable period of time.
 4. The KHCS shall be shut down, stopping both exhaust and make up airflow, whenever the hood fire protection system (e.g. Ansul system) is activated. This shall be accomplished through a control interface between the Ansul panel and the associated exhaust fan's VFD and make up air unit VFD.
- F. Follow-Up Site Service and Inspection: The KHCS manufacturer's representative, with the assistance of the HCS sub-contractor, shall make no less than two (2) site visits in the first two (2) months of the operation of the system. The purpose of the site visits is to inspect each control system for proper operation and make corrections to the adjustable parameters. The representative shall report results in writing for each hood controlled by a KHCS. Report observations made, problems corrected, and any adjustments to the controls or equipment. Make recommendations for any problems not addressed or completely resolved during the site visit.

2.15 CONTROL AND COMMUNICATION WIRING AND CABLES

- A. Electric control wiring shall be in accordance with the National Electrical Code and shall not be in conflict with state and local codes. No control wiring shall be installed in the building lighting and power circuit system.
- B. All conduit, fittings, hangers and accessories for control wiring installed under Division 23 shall conform to installation standards.
- C. Control wiring operating at voltages higher than 30VAC shall be single conductor solid or stranded copper not less than No. 12 AW.G, 90 degrees C., with 600 volt Type THHN/THWN insulation. Wiring in panel construction may be No. 16 or No. 18 AW.G copper provided same is properly protected and/or is in accordance with the NEC.
- D. Low Voltage Cabling (30VAC and less): Twisted (six turns per foot) minimum 22 AW.G wire, with 90 degrees C., 600 volt THHN/THWN insulation. Cable shall have a characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 17 pF per foot. The number of conductors (2, or 3 with a ground conductor) shall be as recommended by the HCS system manufacturer.

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1. Shielded cable shall be provided for analog inputs, for communications between controllers, and for runs exceeding 500 feet. Both foil and braided type shields are acceptable. Ground at one end only; cap the other end. Capacitance between conductors and the shield shall be less than 60 pF per foot.
 2. Use 20 AW.G in runs exceeding 500 feet, but not exceeding 1,000 feet.
 3. Use 18 AW.G in runs exceeding 1,000 feet, but not exceeding 2,000 feet.
 4. Use 16 AW.G in runs exceeding 2,000 feet. Maximum length permitted is 4,000 feet.
 5. Cable used on BACnet MS/TP networks shall be specifically designed and intended by the manufacturer to be used for RS-485 communication.
 6. Cable shall be as manufactured by Alpha Wire Company, Belden Wire Company, Standard Wire and Cable, or approved equal.
- E. Ethernet Cabling: Cat5e or Cat6, copper unshielded twisted pair (UTP), ETL verified to ANSI/TIA-568.2-D. Do not exceed 330 feet of cable length. Provide additional Ethernet switches or hubs to accommodate runs longer than 330 feet. Use solid conductors for runs longer than 50 feet. Conductor shall be min 24 AW.G, except cabling to power-over-Ethernet (POE) devices shall utilize minimum 22 AW.G conductors. Cable shall be as manufactured by Leviton (Berk-Tek), Belden, Commscope, or approved equal. Cat5 cabling shall not be acceptable.
1. All DDC system cabling connecting to the Owner's LAN shall be in full compliance with the Owner's requirements and the provisions of Division 27. In the event of a conflict, between this Section and the Owner's Requirements or Division 27, this Section shall NOT take precedence.
- F. Fire Rated Cables: Power and signal wiring located inside the building and routed between DDC system controllers that are UL864 listed for smoke control and life safety or fire alarm use and the associated field devices (e.g. sensors and controlled devices such as fans, dampers, etc.) shall utilize 2-hour fire rated mineral insulated cables that are UL listed as 'fire resistive alarm cables' and meet NFPA 70 & 72 fire alarm survivability circuit requirements. Route cables in metallic raceways meeting the UL listing requirements.
1. Exceptions: Cables that are routed:
 - a. In a 2-hour rated shaft wall enclosure or stairway enclosure.
 - b. Through a space dedicated to housing fire alarm devices and separated from the remainder of the building by 2hr rated fire barriers (e.g. high rise building fire command center).
 - c. Through metallic raceway and encased in no less than 2-inches of concrete on all sides.

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- d. In a UL listed electrical circuit protective system with a 2-hour fire rating.
- 2. All wiring shall be in an enclosed raceway except that installed inside control panels.
- G. Fiber Optic Cable: Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.
 - 1. Connectors: Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.
 - 2. All DDC system cabling connecting to the Owner's LAN shall be in full compliance with **the** Owner's requirements and the provisions of Division 27. In the event of a conflict, between this Section and the Owner's Requirements or Division 27, this Section shall NOT take precedence.
- H. Plenum Rated Wiring and Cables: Where plenum rated wiring and cables are required, the cable shall have with a peak optical density not greater than 0.50, average optical density not greater than 0.15, and a flame spread distance not greater than 5 feet, when tested in accordance with NFPA 262, as required by the NEC and International Mechanical Code.
 - 1. Ethernet cables shall be UL-verified Limited-Combustible FHC 25/50 CMP cable with an FEP outer jacket.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that conditioned power supply is available to control units and operator workstation.
- B. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with the balance of the control system installation.
- C. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.
- D. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to the Engineer for resolution before starting rough-in work.
- E. Examine the contract documents (Drawings and Specifications) for work of other suppliers and Divisions. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate the work of this Section

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with work of other Divisions or suppliers. The controls contractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

3.2 DEMOLITION AND REUSE OF EXISTING MATERIALS AND EQUIPMENT

- A. The Contractor shall assume that existing equipment that is specifically indicated to be reused is in good condition and is operable. The Contractor during the course of work, shall inspect these devices and determine if any devices are in need of replacement or repair. The Contractor shall prepare an itemized list of suggested repairs/replacement. This repair/replacement will be at the discretion of the Owner and may be accomplished under separate contract, at the Owner's direction.
- B. Existing wiring shall not be reused, and shall be replaced by Contractor. Existing conduit, and control panel cabinets may be reused at the Contractor's discretion, but only if such materials or equipment comply with the applicable specification for new materials and equipment. Such materials shall not be reused if visibly damaged or otherwise unsuitable for the intended service. The Owner does not guarantee the suitability of any such existing materials or equipment for reuse in accordance with the requirements for new materials and equipment.
- C. Where such materials are reused, the contractor's shop drawings shall reflect the existing conduit and cabinet designation. If existing labeling is illegible or otherwise does not comply with the applicable specification for labeling, wiring runs shall be relabeled in accordance with the requirements specified elsewhere.
- D. Existing controllers and point expansion modules that are being replaced as part of this project shall be turned over to the Owner. All other existing control devices and panels that will not be reused shall be disposed of by the Contractor.
- E. Existing electrical service to control panels or devices that are indicated to be demolished or otherwise will not be reused shall be properly terminated and secured per NEC requirements. Label wire with the panel and circuit breaker it is served by. Label wire as "HOT" if circuit cannot be de-energized. If existing electrical circuits only provide power to demolished control panels or devices, then the circuit shall be removed in its entirety (conduit, wire, and supports) back to the originating panel board circuit breaker. Update the panel schedule to reflect the circuit breaker as a "spare".
- F. Existing pneumatic tubing located between the existing BAS panels and the pneumatic operators shall not be reused; however, conduit for such tubing may be reused.
- G. The existing pneumatic main air supply system shall be modified as required and reused to serve existing pneumatic controls that are to remain. Where existing pneumatic controls are being removed, main air piping shall be removed back to the point of connection to the main air supply which remains in use, and shall be capped or plugged.

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- H. The Contractor shall clean and lubricate all damper linkages of control dampers being re-used under this Project.
- I. Other materials and equipment not specifically mentioned herein may be reused only if specifically allowed by indications on the Drawings.
- J. For systems with existing workstation graphics, the existing graphic shall be entirely removed from the system including all links and references and replaced with a new graphic meeting all requirements of the BAS specification Sections. If renovation is only partial, the entire system graphic shall be replaced including devices and equipment that will be reused.
- K. Existing system points shall be released. Partial system renovations shall not be split between old and new points. All points shall be created or recreated to meet the requirements of this Contract.
- L. Extend control power and communication wiring and conduit as required to accommodate the relocation or replacement of existing equipment or motor controllers, and as required to maintain existing equipment otherwise not affected by the scope of the project under full automatic control.
- M. Relocate existing control devices as required to accommodate the relocation of equipment, and as required to maintain existing equipment otherwise not affected by the scope of the project under full automatic control, unless new control devices are explicitly indicated.

3.3 INSTALLATION - GENERAL REQUIREMENTS

- A. Install equipment level and plumb.
- B. Install software in control units and operator workstation. Implement all features of programs to specified requirements and connect and configure equipment and software as appropriate to achieve the sequence of operation.
- C. Do not install control equipment and devices inside airstreams (e.g. inside ducts or air handling equipment air tunnels) unless the proper functioning of the device or equipment demands such an installation, or the equipment/device manufacturer recommends or requires such an installation. Devices and equipment may be installed in above-ceiling spaces that are used as return air plenums.
- D. All control sensing devices shall be installed as to be accessible from the outside of the airstream served.
- E. Verify location of thermostats, humidistats, and other exposed control sensors with plans and room details before installation. Locate all devices that have a manual adjustment or visual read

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out feature in accordance with ADA regulations, 48-inches above the floor, unless noted otherwise on the Drawings. Field coordinate with the work of other trades, and subsequently verify all proposed locations with the Engineer prior to proceeding.

- F. Installations of controllers and input or output control devices outside the building shall be inside NEMA 4X enclosures. Factory devices with a housing of equivalent rating and intended by the manufacturer for exterior installations may be installed outside of enclosures.
 - 1. Wherever possible, install damper motors, duct mounted sensors, and similar devices on outside of duct in weather-protected and warm areas, not in locations exposed to weather and outdoor temperatures.
 - a. Where exterior damper actuator installation cannot be avoided, provide a NEMA 4X enclosure for mounting of the damper actuator, or provide an actuator with an equal or better NEMA rating.
- G. Install labels and nameplates to identify control components according to Division 23 Section "Identification for HVAC."
 - 1. Identify all control wires with labeling tape or sleeves using words, letters, or numbers that can be exactly cross-referenced with as-built drawings. Labels shall be provided within 3" of each wiring connection.
 - 2. Identify all pneumatic and instrumentation pressure signal tubing with a label within 3" of at each connection.
 - 3. All field enclosures, other than controllers, shall be identified with an equipment nameplate. The lettering shall be cross-referenced with as-built drawings.
 - 4. Junction box covers shall be marked to indicate that they are a part of the DDC system.
 - 5. Provide engraved plastic laminate signage, in letters minimum 1/2-inch high, at all space fan start/stop momentary contact buttons, timing switches, etc. The signage shall indicate the switch/system function. A red plate with white letters shall be used for emergency functions, and white with black letters shall be used for normal or non-emergency functions.
 - 6. Control valves shall be provided with a plastic tag with the design GPM and final balance GPM value written in permanent marker. The tag shall be secured to the valve.
 - 7. Label space thermostats, relative humidity sensors, carbon dioxide sensors, and similar space sensors with the name/designation/number of the associated HVAC equipment or air system. For devices controlling a VAV terminal, the name of the VAV terminal only shall be indicated.
- H. Install warning labels as follows:

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1. Affix permanent warning labels to equipment that can be automatically started by the control system.
 - a. Labels shall use white lettering (12-point type or larger) on a red background.
 - b. Warning labels shall read as follows.

C A U T I O N
**THIS EQUIPMENT IS OPERATING UNDER AUTOMATIC CONTROL AND MAY START
OR STOP AT
ANY TIME WITHOUT WARNING. SWITCH DISCONNECT TO "OFF" POSITION BEFORE
SERVICING.**

2. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
 - a. Labels shall use white lettering (12-point type or larger) on a red background.
 - b. Warning labels shall read as follows.

C A U T I O N
**THIS EQUIPMENT IS FED FROM MORE THAN ONE POWER SOURCE WITH SEPARATE
DISCONNECTS. DISCONNECT ALL POWER SOURCES BEFORE SERVICING.**

- I. The Division 23 Contractor shall install:
 1. Hydronic instrument wells, valves, and other accessories according to Division 23 Sections "Hydronic Piping" and "Meters and "Gages for HVAC Piping".
 2. Steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam and Condensate Heating Piping."
 3. Refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping".
 4. Install automatic dampers according to Division 23 Section "Air Duct Accessories."
- J. Install control and interlock wiring.
- K. Seal penetrations to ductwork, plenums, and air-moving equipment to comply with duct static-pressure class and leakage and seal classes indicated using neoprene gaskets or grommets.

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

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- A. General: Provide a complete system of electric wiring for control apparatus. In addition, provide 120 VAC power to terminal equipment controllers and various DDC panels, subpanels, damper actuators and valves if not specifically shown on contract drawings to be provided under Division 26. The HCS contractor shall be responsible for all electrical installation which is necessary to achieve a fully functional HCS system (and which may or may not be shown on the Electrical Drawings, or required by the Division 26 Electrical Specifications). All wiring shall also be in accordance with applicable local and national codes.
- B. Install control wire and cable, raceways, boxes, and cabinets.
- C. Conceal cable and wire in panel enclosures and raceway.
 - 1. Raceway shall be concealed except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Raceway and junction boxes shall be labeled "BAS".
 - 3. Exterior raceway shall be rigid, hot-dipped galvanized steel conduit.
 - 4. Interior raceway shall be EMT, IMC, or rigid galvanized steel conduit.
 - 5. Underground raceway shall be HDPE smooth wall conduit, Schedule 80, ASTM F 2160.
 - 6. Exception: Low voltage control wiring may be routed in plenum-rated cable, without raceway, above accessible ceilings only.
 - a. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.

[Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
 - b. Run parallel with building lines and properly supported by "wedding ring" cable supports and tied neatly to prevent sagging of cable.
- D. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- E. BACnet MS/TP networks shall utilize a series or daisy chain topology, and shall comply with the RS-485 (EIA-485) standard.
- F. No HVAC control wiring installed under this contract shall be installed in conduits for the building lighting and power circuit system.
- G. Connect safety switches and similar high and low limit controls independent of manual-control switch positions.

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- H. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 FIBER OPTIC CABLE INSTALLATION

- A. Fiber optic cable shall be installed in dedicated raceways.
 - 1. Exception: Fiber optics can be run with Ethernet and RS-485 cabling as long as the conduit is bent to fiber optic standards and junction boxes are sized for fiber optic use.
- B. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.
- C. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.6 SPECIFIC INSTALLATION PRACTICES

- A. Controls Systems Wiring:
 - 1. All conduit raceways, wiring, accessories and wiring connections required for the installation of the Controls Systems shall be provided by the DDC Contractor except as explicitly shown on the Electrical Trade documents. All wiring shall comply with the requirements of applicable portions of the Electrical Trade work and all local and national electric codes and the requirements of the AHJ.
 - 2. All Controls Systems wiring materials and installation methods shall comply with the original equipment manufacturer recommendations and standards.
 - 3. The sizing type and provision of cable, conduit, cable trays and raceways shall be the design responsibility of the DDC Contractor.
 - 4. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.
 - 5. Class 2 signal wiring and 24VAC power may be run in the same conduit. Power wiring 120VAC and greater shall not share the same conduit with Class 2 signal wiring.
 - 6. Perform circuit tests using qualified personnel only. Provide necessary instruments and equipment to demonstrate that:
 - a. All circuits are continuous and free from short circuits and grounds.

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- b. All circuits are free from unspecified grounds; that resistance to ground of all circuits is no less than 50 megaohms.
 - c. All circuits are free from induced voltages.
 - 7. Provide complete testing for all cables and wiring. Provide all equipment, tools, and personnel as necessary to conduct these tests.
 - 8. Provide for complete grounding of all signal and communication cables, panels and equipment so as to ensure integrity of Controls Systems operation. Ground cabling and conduit at panel terminations. Do not create ground loops.
 - 9. Each control wire termination at controllers or in control panels shall have wire-labels within 3" of each terminal connection. Wire labeling shall match the final as-built drawings.
- B. Line Voltage Power Sources:
- 1. 120-volt AC circuits for the Controls Systems shall be taken by the DDC Contractor from electrical trade panelboards, circuit breakers, and/or junction boxes, or as designated on the Drawings.
 - 2. Circuits used for the Controls Systems shall be dedicated to these Controls Systems and shall not be used for any other services.
 - 3. DDC terminal unit controllers may use 120-volt AC power serving motor power circuits, but only upstream of the starter or VFD disconnect switch.
 - 4. Provide disconnect switches at all points of 120V power connection to controllers and powered equipment.
- C. Controls Systems Raceways:
- 1. All wiring shall be installed in conduit or raceway except as noted elsewhere in the Specification. Minimum conduit size 3/4".
 - 2. [Where it is not possible to conceal raceways in finished locations on existing masonry or concrete walls, surface raceway (e.g., "Wiremold") may be used. The raceway shall be painted to match that of the adjacent surfaces.]
 - 3. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the supporting surface.
 - 4. UL/ULC Listed Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment supported or hung with external vibration isolation devices.

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5. Provide sealing bushings where cables exit conduits or enclosed raceways, except at connections to control panel enclosures.

D. Penetrations:

1. General: Penetrations shall only be made with sleeves, conduits, and enclosed raceways. Bare cables shall not penetrate walls, floors, roofs, ceilings, duct walls, and equipment casings.
2. Architectural Penetrations:
 - a. Firestopping and smoke stopping for all penetrations used by dedicated controls system conduits and raceways shall be by the HVAC contractor.
 - b. All openings in fire- or smoke- rated elements shall be closed with listed and approved fire resistive sealant or fire stopping sleeves. Refer to Division 07 and Division 23 Section "Common Work Results for HVAC".
 - c. Sleeves shall be used for penetrations through drywall and non-bearing partitions, where cables are otherwise permitted to be installed outside of conduit or enclosed raceway.
 - d. No penetrations through building structural elements, slabs, ceilings and load bearing walls shall be made before receipt of written approval from the Engineer.
 - e. Control signal and control power conduit penetrations of the roof not made inside equipment curbs shall be made through pre-fabricated pipe portals or roof pipe chases, to provide a weather-tight installation.
3. Conduit Penetrations of Ducts:
 - a. Do not drill holes larger than required for passage of conduit or enclosed raceway or sensing element.
 - b. Seal opening with rubber grommet, duct sealant, or rubber gasket-backed flange, as appropriate for the installation.
 - c. Do not make penetrations on the bottom of outdoor air intake ducts.
 - d. Do not install penetrate the top of exterior ducts with fasteners, devices, or raceway.
4. Penetrations of and Air Handling Equipment (e.g. AHUs, fan coils, RTUs, etc.) Casings:
 - a. Drill holes only where approved by the unit manufacturer and in compliance with the manufacturer's recommendations. Do not cut structural frame elements. Do

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not drill holes larger than required for passage of conduit or enclosed raceway. Holes shall not compromise the structural integrity of the casing.

- b. Do not install penetrate the top or roof of exterior HVAC equipment with fasteners, devices, or raceway.
- c. Paint raw edges of galvanized steel sheet with cold galvanized paint.
- d. Penetrations that are not exposed to the weather shall be sealed with silicone sealant and finished over on both sides with a brass or stainless steel escutcheon. Sealant shall fill the annular space between the hole and the conduit, filling the entire depth.
 - 1) Tight fitting spool-shaped rubber grommets are also acceptable. Apply sealant around the hole, behind the lip of the grommet, on both sides of the penetration.
- e. All exterior conduit penetrations in the housing and internal conduit penetrations across the cooling coil sections and humidifier sections, and all sections downstream of the cooling coil and humidifier sections shall be internally sealed with foam sealant to prevent the migration of water vapor in the conduit.
- f. Penetrations that are exposed to the weather shall be made with CSI Designs "Pipetite" seals.
- g. Control cable inside equipment shall be routed in conduit or other enclosed raceway.

E. Controls Systems Identification Standards:

- 1. Controller and Control Panel Identification: All individual controllers and control panels shall be identified by a permanent label fastened to the outside of the enclosure. Labels shall be suitable for the panel's environmental location.
- 2. Cable shall be labeled at every termination with cross-referencing to record documentation.
- 3. Raceway Identification: Exposed covers to junction and pull boxes of the raceways shall be identified at primary points.
- 4. Wire Identification: All low and line voltage wiring shall be identified by a number, as referenced to the associated shop and record drawing, at each termination.
- 5. Wires and cabling shall not be spliced between terminations. Cable shields shall be single end grounded - typically at the panel end outside the panel.

F. Field Panel and Device Installations And Locations:

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1. The Controls Systems panels, enclosures and cabinets shall be located as coordinated with the Engineer at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.
2. All field devices shall be installed per the manufacturer recommendation and in accessible locations as coordinated with the Engineer.
3. Panels shall not be installed in exposed, finished areas of the building unless specifically indicated by Owner. Locate indoor panels in unfinished rooms and above accessible ceilings.
4. Do not install panels inside airstreams (e.g. inside ducts or air handling equipment air tunnels). Panels may be installed in above-ceiling spaces that are used as return air plenums.
5. Panels to be located in damp areas or areas subject to condensation shall be mounted with wall standoffs.
6. Conduit configurations entering or leaving panels and devices shall be such as to preclude condensation traps.

G. Input / Output Control Device Specific Installation Requirements:

1. Water and Steam Flow Meters:
 - a. Input flow measuring devices shall be installed in compliance with ASME Guidelines and the manufacturer's recommendations. Install meter per the manufacturer's recommendations.
 - b. Install meters in straight sections of piping with manufacturer-recommended straight piping upstream and downstream of sensor.
 - c. Install pipe reducers for in-line meters smaller than line size. Install reducers at distance from meter to avoid interference and impact on accuracy.
 - d. In-Line Meters: Install with flanges or unions to provide drop-in and -out installation.
 - e. Insertion Meters: Install system process connections full size of meter connection, but not less than NPS 1. Provide bushing if required to mate to system connection.
 - f. Unless the manufacturer explicitly permits otherwise, install meters in top dead center of horizontal pipe positioned in an accessible location to allow for inspection and replacement. In applications where top-dead-center location is not possible due to field constraints, install meter at location along top half of pipe if acceptable by manufacturer for mounting orientation.

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- g. After water meters have been fully installed in accordance with the manufacturer's recommendations, perform a flow measurement verification with the assistance of the Testing, Adjusting, and Balancing (TAB) Agent performing the work of Division 23 Section "Testing, Adjusting, and Balancing for HVAC". Refer to that Section for additional information.
 - 1) Where recommended by the flow meter manufacturer for the installed condition, or requested by the Engineer, perform a field calibration of the flow meter with the assistance of the Testing, Adjusting, and Balancing Agent.
- 2. Airflow Measuring Stations (AFMSs):
 - a. Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.
 - b. Install sensors in straight sections of duct with manufacturer-recommended straight duct upstream and downstream of sensor.
 - c. Each airflow station application shall be examined by the AFMS supplier and the AFMSs shall be applied such that the specified accuracy is achieved. The specified accuracy requirement shall apply to the entire operating range of the equipment associated with the AFMS. These conditions shall be met when the AFMSs are applied according to the manufacturer's guidelines. This application shall be done based on actual field conditions (through the process of generating ductwork shop drawings and coordination drawings) and not Contract Documents. Any station not complying with the manufacturer's installation guidelines shall be so noted in the submittal process. The submittals for the AFMSs shall include tag, range, output, size, product accuracy, installed system accuracy, sensor density, installation type, and all other relevant data to access the AFMSs and their performance.
 - d. After airflow measuring stations have been fully installed in accordance with the manufacturer's recommendations, perform a flow measurement verification with the assistance of the Testing, Adjusting, and Balancing (TAB) Agent performing the work of Division 23 Section "Testing, Adjusting, and Balancing for HVAC". Refer to that Section for additional information.
 - 1) Where recommended by the airflow station manufacturer for the installed condition, or requested by the Engineer, perform a field calibration of the station with the assistance of the Testing, Adjusting, and Balancing Agent.
 - e. Installed airflow stations shall be accessible for visual inspection and service. Install access doors in duct or equipment located both upstream and downstream of

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sensor, to allow service personnel to inspect and hand clean the stations. Adequate clearance to other work shall be provided so that airflow stations can be replaced without requiring the removal of other work.

- f. An identification label shall be placed on each station listing the model number; system served, size and identifying tag number.
 - g. Differential Pressure Based Airflow Measuring Density Correction: The DDC system shall employ an air density correction factor to the airflow rate calculation performed for converting differential pressure signals from pitot tube and piezo ring stations to airflow values. Provide an analog input temperature sensor in the airstream for purposes of providing this active density correction.
3. Pressure and Differential Pressure Sensors and Switches:
- a. Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.
 - b. Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.
 - c. The transmitters shall be installed in an accessible location.
 - d. Install pressure-sensor needle valve and snubber in piping to pressure gages.
 - e. Provide syphons and needle valves on piping to steam pressure sensors.
4. Indoor-Outdoor Differential Air Pressure Applications:
- a. The transmitter's exterior (low pressure) port shall be piped through a high volume accumulator and terminated with a shielded static air probe to reduce pressure fluctuations caused by wind. Pipe high-pressure port to a location behind a thermostat cover.
 - b. The interior tip shall be located in an inconspicuous location approved by the Engineer/Engineer prior to installation.
5. Exterior Duct, Plenum and AHU Differential Air Pressure Applications:
- a. The transmitter's exterior (reference) port shall be piped through a high volume accumulator and terminated with a shielded static air probe to reduce pressure fluctuations caused by wind.
 - b. Provide the duct, plenum, or AHU pressure port all with static pressure tips, tubing, fittings and air filter.

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6. Indoor Duct and AHU Air Differential Pressure Sensors and Status Switches:
 - a. Install with static pressure tips, tubing, fittings and air filter.
7. Medium to High Differential Air Pressure Applications (Over 10" w.g.):
 - a. In addition to other requirements specified above, provide air bleed units, bypass valves, and compression fittings.
8. Outdoor Air Temperature Sensors:
 - a. Sensors shall be mounted on a wall selected to minimize solar radiant heat impact or be located in a continuous intake flow adequate to monitor outside air conditions accurately.
 - b. Sensors shall be installed with a weather shield.
 - c. Sensors shall be mounted on the North wall (and provided with a weather or sun shield) to minimize solar radiant heat impact or located in continuous intake airflow adequate to monitor outside air conditions accurately.
 - d. Do not locate sensors near exhaust or relief air discharges. Maintain minimum 20 foot separation.
 - e. Do not locate above doors or operable windows.
 - f. Locate a minimum of 10 feet above adjacent finished grade and roof surfaces.
9. Duct and Plenum Temperature Sensors:
 - a. Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.
 - b. The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.
 - c. Use averaging type sensors in ductwork greater in any dimension than 48 inches, where air temperature stratification exists (such as a mixed air plenum), immediately downstream of an air blender, and immediately downstream of any heat exchanging element (coil, furnace, energy recovery heat exchanger, etc.)
 - d. Install averaging elements in ducts and plenums in a zigzag pattern, with evenly spaced passes. When horizontal stratification is anticipated, the pattern of passes shall be a vertical zigzag. When vertical stratification is anticipated, the pattern shall be a horizontal zigzag. When the stratification is unknown or complex, the

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element passes shall be set at approximately a 45 degree angle. Element length shall be sufficient such that each square foot of flow area of the duct, plenum, cabinet /air tunnel, or associated coil is provided with no less than 1 linear foot of sensing element. Provide multiple sensors as required.

- e. The sensor shall be mounted to suitable supports using factory approved element holders.
- f. Support each bend in capillary with approved safe radius clips. Clips shall be non-metallic. Dwyer series 'CC1' or approved equal.

10. Low Temperature Limit Switches (Freezestats):

- a. Install on the discharge side of the first hydronic coil in the air stream, or as indicated on the Drawings or in the sequences of operation.
- b. Mount element horizontally across duct in a uniform, horizontal serpentine pattern insuring each square foot of coil is protected by no less than 1 linear foot of sensing element. Provide as many freezestats as required for full coverage.
- c. Element shall be exposed to all areas that encounter low temperature, including along the bottom of the coil(s), from end to end.
- d. Mount freezestats across the coil face in accordance with manufacturers recommended installation procedures. Do not kink or compress the sensing tube. Ensure that there are no sharp bends in the element and there are no kinks in the capillary tube. Tubes that are kinked shall require the freezestat to be discarded and replaced.
- e. Support bends in the capillary element with approved safe-radius clips. Clips shall be non-metallic. Dwyer series 'CC1' or approved equal.
- f. Provide intermediate supports to prevent excessive vibration of the element, or contact with other items.
- g. Install a rubber grommet or bushing where the sensing element passes through sheet metal openings to both seal the opening and protect element from vibrational wear on the opening.
- h. Allow unrestrictive access to the manual reset button, and label the device.

11. Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke.

- a. Damper actuators shall not be installed inside ducts unless specifically indicated on the Drawings, or approved by the Engineer.

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12. Control Valve Protection: Coordinate with the work of other suppliers in this Division to ensure that control valves are protected with a local strainer as detailed on the Drawings, upstream of the control valve, with a straining element of a mesh size appropriate to protect the valve performance and maintain the valve warranty and comply with the control valve manufacturer's recommendations. Pressure independent control valves shall be provided with a 20 mesh, or finer, straining screen.
13. Control Valve and Actuator Installation Orientation:
 - a. Quarter-Turn Control Valves (Butterfly, Ball, V-Ball)
 - 1) For hydronic applications, preferred valve orientation is with shaft oriented horizontally. Valve shall not be installed such that shaft is oriented vertically downward (i.e. with actuator at bottom).
 - 2) For steam applications, valves/actuators shall be installed such that shaft is oriented horizontally. In no case shall valve be oriented in vertically upward position. (vertical upward orientation results in overheating of actuator and accessories).
 - b. Globe Control Valves:
 - 1) For hydronic applications, valve shall be installed such that the stem is oriented within 45 degrees of the vertical upward position. If this orientation cannot be practically achieved, valve may be installed such that stem is oriented horizontally. In no case shall valve be installed such that stem is oriented vertically downward.
 - 2) For steam applications, valve shall be installed such that stem is not oriented in the vertically upward position (to prevent overheating of actuator and accessories). Preferred orientation is 45 degrees from vertically upward position. If this orientation cannot be practically achieved, valve may be installed such that stem is oriented horizontally. In no case shall the valve be installed such that stem is oriented vertically downward.
14. Control Valve Sizing:
 - a. Modulating Pressure-Dependent Control Valves: Modulating valves shall be sized for proper flow control with equal percentage characteristics for 2-way hydronic valves, and linear characteristics for 3-way hydronic valves, and for 2-way hydronic minimum system flow bypass valves. Use the sizing criteria below to determine the required Cv for each valve. When the Cv required is between two available valve sizes, select the larger size.

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- 1) Modulating Hydronic Applications: Unless indicated otherwise, the required valve pressure drop for modulating hydronic valves (both 2-way and 3-way types) shall be equal to 50% of the pressure drop scheduled on the Drawings for associated equipment (i.e., coils, heat exchanger), or a maximum of 5 psi at design maximum capacity.
- 2) Valves also be sized so they will not cavitate with an absolute inlet pressure of 20 psig at the maximum anticipated operating fluid temperature.
 - a) Exception: Hydronic minimum flow bypass valves shall be sized for the required minimum system flow rate at the lowest available differential pressure anticipated at the location of the bypass valve. Round up to the nearest available Cv value or valve size.
- 3) Modulating steam valves shall be sized for 2.5 psi at design maximum capacity.
- b. Two-Position Pressure-Dependent Control Valves: All two-position valves (all services - both hydronic and steam; both 2-way or 3-way) shall be full line size.
- c. Pressure-Independent Characterized Control Valves (PICCVs): Select valves based on scheduled design flowrate. The maximum valve GPM shall be manually adjustable within a range of flow, and the required design GPM for each coil, heat exchanger, etc. as scheduled on the Drawings shall be no more than 75% of the maximum possible for the selected valve and no less than 20% though the valve's adjustment range. (Example: A valve with a 2 to 5 GPM maximum flow range would be suitable for a coil with a scheduled design flow between 2.6 and 3.75 GPM).
 - 1) Tag valves with GPM range and model number.
15. Electronic Signal Isolation Transducers: Whenever an analog output signal from the DDC system is required to be connected to an external control system as an input (such as the packaged controls on a chiller control panel), or it is to receive as an input a signal from an external system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between building systems. Provide optical isolation between building systems.
16. Flow Switches: Use correct product for pipe diameter. Adjust flow switch according to manufacturer's instructions.
17. Space Thermostats and Temperature Sensors: Room thermostats and temperature sensors shall be installed at locations indicated on the Drawings, however the control manufacturer shall carefully check the Architectural and Electrical Drawings to verify the locations indicated. Any relocation of room thermostats to avoid conflict with other

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trades or at the control manufacturer's recommendation to improve performance, shall be only as approved by the Engineer.

18. Space Control Device Guards: Room temperature sensors, thermostats, humidity sensors, space CO2 sensors, and similar wall mounted control devices located in toilet rooms, corridors, lobbies, gymnasiums, cafeterias, locker rooms, unsupervised areas, and where indicated on the Drawings shall be protected with guards securely anchored to the wall.
 - a. Clear plastic anti-tamper type shall be used except as noted otherwise.
 - b. Devices in gymnasiums, locker rooms, loading docks, and similar areas where devices may be subject to abuse, and where indicated on the Drawings shall be provided with protective anti-tamper perforated steel type guards.
19. Occupancy Sensors: Provide all related parts and accessories for a complete working system. Install devices in rooms indicated. Ceiling mounted occupancy sensors shall be installed centered in ceiling tiles. Install no less than the quantity of occupancy sensors indicated on the plans. Occupancy sensors shall be installed such that the sensor has unobstructed coverage of the entire space. Final layout and quantity of sensors shall be the responsibility of the occupancy sensor supplier or vendor, and shall be in full accordance with the sensor manufacturers recommendations. Layout and quantity shown on the Drawings are for design intent only.
20. Pneumatic Devices:
 - a. Electric solenoid operated pneumatic (EP) valves and current to pneumatic (I/P) transducers shall be installed in approved electrical enclosures or in apparatus control panels.

3.7 COORDINATION WITH THE TESTING ADJUSTING AND BALANCING AGENT

- A. Refer to Division 23 Section "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures requiring manipulation of DDC system control parameters.
- B. Coordinate with the TAB Agent or sub-contractor and with the Commissioning Agent to fine tune control settings that are determined from balancing procedures. Record the following control settings as obtained from TAB contractor, and note any TAB deficiencies in writing:
 1. Optimum duct static pressure setpoints for VAV air handling units.

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2. Minimum outside air damper settings for constant volume air handling units.
 3. Optimum differential pressure setpoints for variable speed pumping systems.
 4. Calibration parameters for flow control devices such as VAV boxes or air valves and duct and piping flow measuring stations/ meters.
- C. Assist the TAB Agent in performing testing and balancing of variable volume air and hydronic distribution systems, and testing of such systems that have flow diversity by manipulating air and water flow at each control terminal or valve through the DDC system, as directed by the TAB Agent.
- D. Airflow Control Terminals: BAS Contractor shall provide a hand held device as a minimum to the TAB Agent to facilitate airflow control terminal (e.g. VAV box) calibration. Connection for any given device shall be local to it (i.e. at the VAV box or at the thermostat). Portable operator's terminal shall allow querying and editing of parameters required for proper calibration and start up.
1. Train the Testing and Balancing Agent to use control system interface tools.
 2. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
- 3.8 COMMISSIONING OF THE CONTROL SYSTEM BY THE DDC SYSTEM SUPPLIER or SUB-CONTRACTOR
- A. Commissioning of the system shall be complete before acceptance by the Owner.
- B. Pre-Testing Quality Control: Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment, and retest. Verify the following:
1. Verify operation of human machine interface.
 2. Verify local control units including self-diagnostics.
 3. Verify that the specified I/O capacity has been provided.
 4. Verify that DDC controller power supply is from emergency power supply, where applicable.
 5. Verify that wires at control panels are tagged with their service designation matching that shown on the shop drawings.
 6. Check control valves. Verify that they are piped with the flow in correct direction.
 7. Check dampers to verify proper blade arrangement, either parallel or opposed, has been provided, and that the dampers fully close and open.

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- C. General Testing Procedures: Each phase of testing shall be completed and accepted before proceeding to the next step of testing. It shall be the responsibility of the DDC system supplier to coordinate and schedule the required trades and technicians required to complete testing. Project completion delays caused by inadequate coordination and scheduling or delays caused by failure to meet these commissioning specifications shall be the responsibility of this Contractor.
1. Test plans shall be developed for each phase of testing by the DDC system supplier and shall define all the tests required to ensure that the system meets all requirements of the Contract Documents. 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.
 2. Test reports shall be used to document the results of each test.
 3. Testing shall be performed in two basic phases:
 - a. Phase One - General Performance Testing verifies the accuracy of the sensors and end devices and general system operation, flexibility and response.
 - 1) Written permission shall be obtained from the Owner that this phase of testing has been successfully completed with the proper documentation before proceeding with the next phase of testing.
 - b. Phase Two - Functional Testing is operational sequence testing which verifies the proper operation of control strategies to match the sequence of operation.
- D. Phase One Testing - General Performance Testing: Calibration of each instrumentation device connected to the DDC system shall be performed by making a comparison between the reading at the respective device and the display at the supervisory HMI using a standard which is traceable to the National Bureau of Standards and shall be at least twice as accurate as the device to be calibrated.
1. All input devices (flow measuring stations, sensors or transducers, etc.) shall be tested to verify that they meet the accuracy as specified.
 - a. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - b. For each analog instrument, make a three-point test of calibration for both linearity and accuracy.
 - c. Equipment and procedures used for calibration shall meet instrument manufacturer's recommendations.
 - d. Provide diagnostic and test equipment for calibration and adjustment.

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- e. Field instruments and equipment used to test and calibrate installed instruments shall have accuracy at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
 - f. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - g. If, after-calibration-indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - h. Comply with field-testing requirements and procedures indicated by ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements of the device manufacturer, and to supplement requirements indicated.
2. The Phase One General Performance Tests shall be used to demonstrate the specified overall system performance and accuracy of the DDC system. System performance shall be verified on all systems on the specified failure modes upon DDC system failure or loss of power, and that all systems return to DDC system control automatically upon resumption of DDC system operation or return of power. Exercises shall be performed on the system according to the written test procedures in order to verify response time of all system activities (i.e., control loop response, alarm response, updating of temperatures, and other values). This testing shall also include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
- a. Network:
 - 1) Controller to controller data transfer time.
 - 2) Supervisory console to controller transfer time.
 - 3) Network reconfiguration.
 - 4) Network error recovery.
 - b. System Controller and HMI:
 - 1) Scan rate.
 - 2) Analog input/output accuracy.
 - 3) Battery back-up duration.
 - 4) Screen refresh rate.
 - c. Sensors:

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- 1) Visually inspect for proper installation and electrical connections.
 - 2) If the process variable can be simulated, input 0% range value and record the measured process variable, device output and displayed value at the DDC system terminal. Repeat this process for 50% and 100% of the process variable range.
 - 3) If the process variable cannot be simulated, use the ambient value for the process variable and record the measured process variable, device output and displayed value at the DDC system terminal. Simulate the device output signal current/voltage for 0% and 100% of the process variable range and record the measured device output signal and the displayed value at the DDC system terminal.
- d. Transducers:
- 1) Visually inspect for proper installation and electrical connections.
 - 2) Enter 0% range value at the DDC system terminal and measure and record the device's input and output signal values. Repeat for 50% and 100% of device's range.
- e. Control Valves and Dampers:
- 1) Visually inspect for proper installation and electrical connections.
 - 2) Enter 0% range value at the DDC system terminal and measure and record the device's input and output signal values. Repeat for 50% and 100% of device's range.
 - 3) Step the final element from 0% to 100% range value at the DDC system terminal and measure and record the device's 0% to 100% speed. Repeat for 100% to 0% of device's range.
- f. Control Valve Leak Check: Verify proper close off of all control valves. Ensure the valve seats properly by simulating the maximum anticipated pressure difference across the circuit. Calibrate air temperature sensors on each side of coil to be within 0.5°F of each other. Via the operator's interface or workstation, command the valve to close. Energize fans. After 5 minutes observe air temperature difference across coil. If a temperature difference is indicated, and the piping surface temperature entering the coil is within 3°F of the water supply temp, leakage is probably occurring. If it appears that it is occurring, close the isolation valves to the coil to ensure the conditions change. If they do, this validates the valve is not closing. Remedy the condition by adjusting the stroke and range, increasing the actuator size/torque, replacing the seat, or replacing the valve as applicable.

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- g. Miscellaneous:
 - 1) Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
 - 2) Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
 - 3) Check each alarm with an appropriate signal at a value that will trip the alarm.
 - 4) Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
 - 5) Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.
- 3. Documentation: Prepare a report documenting results. Include a log documenting startup testing of each input and output device, with technician's initials certifying each device has been tested and calibrated.
- E. Phase Two Testing - Operational Sequence or Functional Testing: Operational sequence testing shall be performed to verify compliance of the completed DDC system with the Contract Documents. Using approved test procedures, all physical and functional requirements of the project shall be tested. Provide and schedule operational testing for each season (winter, summer, etc.) applicable to specific control sequence.
 - 1. Phase Two - Operational Sequence or Functional Testing as specified shall not be started until after successful completion of the Phase 1 - General Performance Testing as specified above and submission of the Phase 1 report.
 - 2. Phase Two testing for systems and equipment that incorporate factory mounted and packaged controls shall involve the participation of the Installing Contractor, representatives of the equipment supplier or manufacturer, and the DDC system provider. Refer to other Division 23 specifications for the equipment and related systems requiring this form of cooperative testing effort.
 - 3. The Engineer and Commissioning Agent reserve the right to observe Phase 2 testing. Notify these parties no less than 7 days before testing begins.
 - 4. Testing procedures shall include the following:

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- a. Simulate and observe each individual control loop during each applicable operational mode by overriding and varying inputs and schedules.
 - b. Tune all control loops to obtain the fastest stable response without hunting, offset or overshoot. Where auto-tuning software is used record the final operating parameters. Auto-tuning software shall not be allowed to continuously adjust parameters as this may lead to masking other device or system problems. Record tuning parameters and response test results for each control loop.
 - 1) Obtain graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Perform further tuning of each loop that displays unreasonably under- or over-damped control.
 - c. Test the building fire alarm system interface.
 - d. Test demand limiting modes of operation by obtaining trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting setpoint, and status of setpoints and other affected equipment parameters.
5. Documentation: Submit a report of testing results with trend data where appropriate. An operational test verification form shall be completed for each control loop. Any deviations or unsatisfactory results shall be noted in the remarks and signed and dated by the DDC system supplier's field engineer.
- F. Functional Performance Demonstration: At the request of the Engineer, Owner, or the Commissioning Agent, the DDC system provider shall provide a demonstration of the system performance. During this demonstration, the DDC system provider shall demonstrate actual field operation of each sequence of operation of each system in a manner similar to the Functional Performance Testing specified above. Provide at least two persons equipped with two-way communication. Demonstrate response of any input and output points requested by the Engineer, Owner or Commissioning Agent. Provide and operate test equipment required to prove proper system operation. Verify calibration of field devices where requested.

3.9 SOFTWARE OPTIMIZATION ASSISTANCE

- A. The BAS Contractor shall provide the services of a controls technician as specified above at the project site to be at the disposal of the Owner, Engineer, and Commissioning Agent. The purpose of this requirement is to make changes, enhancements and additions to control unit

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and/or workstation software and sequence of operation that have been identified by during the commissioning of the project or during the warranty period that are beyond the specific requirements of the contract documents.

- B. The cost for a total of 40 hours of this service shall be included with the bid. The allotted hours may occur over as many as ten (10) separate service calls. Unused training hours shall be used for additional software optimization assistance, at the Owner's request.
- C. The controls technician provided shall be thoroughly trained in the programming and operation of the controller and workstation software. If the controls technician provided cannot perform every software task requested in a timely fashion, contractor shall provide additional qualified personnel at the project site with deduction from the allotted hours of service.

3.10 OWNER DEMONSTRATION AND TRAINING

- A. The Controls Contactor shall provide the following training services for the Owner's key personnel at common sessions.
 - 1. Training shall not be less than a total of 16 hours, spread out over as many as 4 days (4 hours per day). Unused software optimization assistance hours shall be used for additional training, at the Owner's request.
 - 2. Specific schedules shall be established at the convenience of the Owner. The classes may be spread out during the Warranty Period as per the Owner's wishes.
 - 3. Training shall not begin prior to system commissioning and acceptance by the Owner.
 - 4. This training shall be conducted by Field Engineer who is fully knowledgeable of the specific installation details of the Project.
- B. Prior to beginning training, conduct a walk-through of the Project to identify panel and device locations and to explain system operation.
- C. The training program(s) shall be designated to provide a comprehensive understanding and basic level of competence with the system. It shall be sufficiently detailed to allow customer personnel to operate the system independent of any outside assistant. The training shall be completed on the actual installed direct digital control system.
- D. Online context sensitive HELP screens shall be incorporated into the system to further facilitate training and operation.
- E. The training plan shall include detailed session outlines and related reference materials. The customer personnel shall be able to utilize these materials in the subsequent training of their co-workers.

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- F. Training sessions shall enable students to accomplish the following objectives, at the minimum.
1. Understand the Project 'as-built' documentation.
 2. Understand naming conventions.
 3. Proficiently operate system.
 4. Understand control system Architecture and configuration.
 5. Understand DDC system components.
 6. Understand system operation, including DDC system control and optimizing routines (algorithms)
 7. Operate workstation and peripherals.
 8. Log on and off system.
 9. Access graphics, point reports, and logs.
 10. Adjust and change system setpoints, time schedules, and holiday schedules.
 11. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools.
 12. Understand system drawings and Operation and Maintenance manual.
 13. Understand job layout and location of control components.
 14. Access data from DDC controllers.
 15. Operate portable operator's terminals.
 16. Create and change system graphics.
 17. Create, delete, and modify alarms, including configuring alarm reactions.
 18. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs.
 19. Configure and run reports.
 20. Add, remove, and modify system's physical points.
 21. Create, modify, and delete application programming.
 22. Add operator interface stations.
 23. Add a new controller to the system.
 24. Download firmware and advanced applications programming to a controller.
 25. Configure and calibrate I/O points.

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26. Interface with job-specific, third-party operator software.
27. Maintain software and prepare backups.
28. Understand system cybersecurity features and functions.
29. Understand procedures for software updates and applying security patches.
30. Add new users and set access restrictions.
31. Understand password security procedures, including 2-factor authentication.

3.11 OWNER DEMONSTRATION AND TRAINING VIDEO RECORDINGS

- A. General: The DDC system supplier or sub-contractor shall video record demonstration and training sessions. 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. Video: Provide minimum 640 x 480 video resolution converted to.mp4 format file type, on electronic media.
 1. Electronic Media: Read-only format compact disc acceptable to Owner, with commercial-grade graphic label.
 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 upon 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 DVD that describes the following for each Contractor involved on the Project, arranged according to Project table of contents:
 - a. Name of Contractor/Installer.
 - b. Business address.
 - c. Business phone number.
 - d. Point of contact.
 - e. E-mail address. (a.k.a., HVAC Control System)

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- 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. Pre-Produced Video Recordings: Provide video recordings used as a component of training modules in same format as recordings of live training.
- F. Owner shall have right to make additional copies of video for internal use without paying royalties.

END OF SECTION 23 0900