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SECTION 012300 – ALTERNATES

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 alternates.

1.3 DEFINITIONS

- A. Alternate: An amount proposed by bidders and stated on the Bid Form for certain work defined in the bidding requirements that may be added to or deducted from the base bid amount if Owner decides to accept a corresponding change either in the amount of construction to be completed or in the products, materials, equipment, systems, or installation methods described in the Contract Documents.
  - 1. Alternates described in this Section are part of the Work only if enumerated in the Agreement.
  - 2. The cost or credit for each Alternate is the net addition to or deduction from the Contract Sum to incorporate an Alternate into the Work. No other adjustments are made to the Contract Sum.

1.4 PROCEDURES

- A. Coordination: Revise or adjust affected adjacent work as necessary to completely integrate work of the Alternate into Project.
  - 1. Include as part of each Alternate, miscellaneous devices, accessory objects, and similar items incidental to or required for a complete installation whether or not indicated as part of Alternate.
- B. Execute accepted Alternates under the same conditions as other Work of the Contract.
- C. Schedule: A Schedule of Alternates is included at the end of this Section. Specification Sections referenced in this Schedule contain requirements for materials necessary to achieve the work described under each Alternate.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 SCHEDULE OF BID ALTERNATES

- A. Bid Alternate No. 1: Two-story building expansion to the south end of Area A.
  - 1. Base Bid: For Area A, construct the 16-classroom, two-story wing as indicated on Sheets A002, A004 and A006. All corresponding civil/landscape, structural, fire protection, plumbing,

mechanical and electrical sheets for this building footprint shall apply to the Base Bid construction for Area A.

2. Bid Alternate: For Area A, construct the 24-classroom, two-story wing as indicated on Sheets A003, A005 and A007. All corresponding civil/landscape, structural, fire protection, mechanical and electrical sheets for this building footprint shall apply to the Bid Alternate No. 1 construction for Area A. The Bid Alternate No. 1 pricing shall account for the cost difference between constructing the 24-classroom building in lieu of the 16-classroom building.

**B. Bid Alternate No. 2: A/B Connector and Area B Alteration**

1. Base Bid: Base Bid Work, as follows:
  - a. Construct a free-standing canopy between Area A and Area B, as indicated on Sheet A410 and all corresponding civil/landscape, structural and electrical sheets.
  - b. Connect existing Area B fire alarm system to the new construction fire alarm system in MDF Room in Area C, as indicated on Sheets E00.02, ED1.02, and E09.02. Demolish abandoned Simplex FACP in Area B.
  - c. Add electrified hardware and pathways for Door B100 to be outfitted with card reader latch retraction, as indicated in Specification Section 087111 Door Hardware Sets. Location of Door B100 shown on Sheet A102.
  - d. Construct the north wall of Area A as a 1-hour fire-resistance-rated exterior wall, as indicated on Sheets A100 and A106.
  - e. Demolish existing interior room identification signage in Area B corridors and install new interior room identification signage for Area B rooms, as indicated on Sheet I106.
  - f. Coat the existing standing-seam metal roof, metal wall panels, gutters and downspouts to match the color of the new construction standing-seam metal roof on Area A. See Specification Section 099113 Exterior Painting for coating system.
2. Bid Alternate: Construction of built connector between Areas A and B, plus alteration of Area B, as indicated on Sheets A003, A411 and all corresponding civil/landscape, structural, fire protection, plumbing, mechanical and electrical sheets, that includes the following:
  - a. Construction of a building connector between Areas A and B, in lieu of the free-standing canopy between Areas A and B, as indicated on Sheet A411 and all corresponding civil/landscape, structural, fire protection, plumbing, mechanical and electrical sheets for this building connector footprint shall apply to the Bid Alternate No. 2 construction.
  - b. Elimination of the 1-hour fire-resistance-rating of the north wall of Area A. This exterior wall shall not be fire-resistance-rated as shown on Sheet A102.
  - c. Retain the connection of the existing fire alarm system to the new system, the electrified hardware and pathways for Door B100, the new interior room identification signage, and coating the existing standing-seam metal roof, metal wall panels, gutters and downspouts for Area B as indicated for the Base Bid.
  - d. Demolition of existing classroom casework and installation of new classroom base and wall cabinets.
  - e. Demolition of existing ceiling grids, ceiling tiles, and light fixtures; installation of sprinkler system, new ceiling grids, new ceiling tiles, new lighting/switches, and cleaning of existing mechanical diffusers.
  - f. Demolition of all toilets, urinals, sinks, drinking fountains and toilet partitions in girls/boys group toilet rooms and two staff toilet rooms; installation of new toilets, urinals, sinks, drinking fountains and toilet partitions in girls/boys group toilet rooms and two staff toilet rooms.



- g. Demolition of all existing receptacles and faceplates throughout Area B; retain all existing receptacle pathways and wiring; installation of new tamper-resistant receptacles and faceplates throughout Area B, as indicated on electrical drawings.
    - h. Demolition of existing 6" high black rubber wall base throughout Area B corridors; installation of new 6" high black rubber wall base throughout Area B corridors.
    - i. Re-painting the exposed surfaces of all existing lockers.
    - j. As indicated on electrical drawings: installation of classroom technology upgrades, including HDMI ports for roll-in TV/Smartboard, pathways and cabling for new ceiling-mounted projector, and installation of new intercom outlets.
  - C. Bid Alternate No. 3: New Area B standing-seam metal roof system, metal wall panels, gutters, and downspouts.
    - 1. Base Bid: Area B existing standing-seam metal roof, metal wall panels, gutters, and downspouts shall be coated to match the color of the new construction standing-seam metal roof on Area A. See Specification Section 099113 Exterior Painting for coating system.
    - 2. Bid Alternate: For Area B, demolish standing-seam metal roof system, insulation and other components down to existing metal roof deck to remain; demolish metal wall panels, their support framing and insulation down to the sheathing to remain; demolish gutters and downspouts down to downspout boot to remain. Provide and install new standing-seam metal roof panel system, roof insulation, coverboard and air/moisture barrier, new air barrier on existing wall sheathing, new metal wall panels with support framing, new gutters and downspouts as indicated on Sheets A007 and A342.
  - D. Bid Alternate No. 4A: VCT flooring and resilient base in corridors in Areas A (Base Bid Building Footprint), C and D; and in Dining. Tile carpet flooring and resilient base in Reception. **Quarry Tile and Quarry Tile Base in Trash Room.**
    - 1. **Base Bid: Provide Terrazzo Base and Terrazzo as the flooring finish in corridors in Area A (Base Bid Building Footprint), C and D; and in Dining, Trash Room, and Reception. Field and accent colors and patterns as shown on Interior Finishes Plans.**
    - 2. Bid Alternate: Provide and install Resilient Base and VCT flooring in lieu of Terrazzo in Area A first floor corridors (Base Bid Building Footprint), Area A second floor corridor (Base Bid Building Footprint), Area C main corridors and vestibule, Area D corridors and vestibule, and in Dining. Provide and install Resilient Base and Carpet Tile in lieu of Terrazzo in Reception. Provide and install Quarry Tile Base and Quarry Tile in lieu of Terrazzo in Trash Room. Field and accent colors and patterns as shown on Interior Finishes Plans.
  - E. Bid Alternate No. 4B: VCT flooring and resilient base in corridors in Areas A Building Expansion (Bid Alternate No. 1).
    - 1. Base Bid: Provide Terrazzo Base and Terrazzo as the flooring finish in Area A first floor and second floor corridors constructed only as part of Bid Alternate No. 1. Field and accent colors and patterns as shown on Interior Finishes Plans.
    - 2. Bid Alternate: Provide Resilient Base and VCT flooring in lieu of Terrazzo in Area A first floor and second floor corridors constructed only as part of Bid Alternate No. 1. Field and accent colors and patterns as shown on Interior Finishes Plans.
- 3.2 SCHEDULE OF PREFERRED-BRAND-ALTERNATES
- A. Bid Alternate No. 5: Fire Alarm System

1. Base Bid: Provide Fire Alarm System by an approved manufacturer.
  2. Bid Alternate: Provide Fire Alarm System by Fire Lite.
  3. Preferred Brand Alternate Explanation:
    - a. Standardizing on Fire Lite allows limited down time with limited amount of stock. A Fire Lite system currently exists in Area B, and continuing with Fire Lite allows for installation and programming standardization system-wide and allows for ease of global software updates, which minimizes downtime and maximizes personnel resources.
- B. Bid Alternate No. 6: Building Automation System (BAS)
1. Base Bid: Building Automation System by an approved manufacturer.
  2. Bid Alternate: Provide Building Automation System by Trane.
  3. Preferred Brand Alternate Explanation:
    - a. The use of Trane controls provides lower maintenance costs, quick, reliable, and locally-available authorized service, and consistent standards between many schools, which provides ease of maintenance and training.
- C. Bid Alternate No. 7: Door Cylinders and Locks
1. Base Bid: Provide Door Cylinders and Locks as scheduled by single source manufacturer.
  2. Bid Alternate: Provide Door Cylinders and Locks by Sargent; Series 7900 Mortise Locks and Series 6300 IC Cores.
  3. Preferred Brand Alternate Explanation:
    - a. Sargent cylinders and locks are high quality and improve the functioning of the maintenance department because the owner only has to stock replacement parts for one type of lock and cylinder. Using only one product reduces the overall required training and decreases the manhours required for repairs. Also, standardizing on Sargent cylinders and locks allows the owner to keep (or form) a Grand Master keyway system which is an important security feature. This item is being bid as an alternate due to the long-term cost savings received through the product's quality, durability, and inventory stocking by WCPS.
- D. Bid Alternate No.8: Door Exit Devices
1. Base Bid: Provide Door Exit Devices as scheduled by any approved manufacturer.
  2. Bid Alternate: Provide Door Exit Devices by Von Duprin.
  3. Preferred Brand Alternate Explanation:
    - a. Von Duprin exit devices are high quality and improve the functioning of the maintenance department because the owner only has to stock replacement parts for one type of exit device. Using only one product reduces the overall required training and decreases the manhours required for repairs. This item is being bid as an alternate due to the long-term cost savings received through the product's quality, durability, and inventory stocking by WCPS.
- E. Bid Alternate No. 9: Door Closers
1. Base Bid: Provide Door Closers as scheduled by any approved manufacturer.
  2. Bid Alternate: Provide Door Closers by Sargent.
  3. Preferred Brand Alternate Explanation:
    - a. Sargent closers are high quality and improve the functioning of the maintenance department because the owner only has to stock replacement parts for one type of closer. Using only one product reduces the overall required training and decreases the manhours required for repairs.

This item is being bid as an alternate due to the long-term cost savings received through the product's quality, durability, and inventory stocking by WCPS.

F. Bid Alternate No. 10: Door Overhead Stops & Magnetic Holders

1. Base Bid: Provide Door Overhead Stops & Magnetic Holders as scheduled by any approved manufacturer.
2. Bid Alternate: Provide Door Overhead Stops & Magnetic Holders by Sargent.
3. Preferred Brand Alternate Explanation:
  - a. Sargent overhead stops and magnetic closers are high quality and improve the functioning of the maintenance department because the owner only has to stock replacement parts for one type of overhead stop and one type of magnetic closer. Using only one product for each hardware type reduces the overall required training and decreases the manhours required for repairs. This item is being bid as an alternate due to the long-term cost savings received through the product's quality, durability, and inventory stocking by WCPS.

END OF SECTION 012300

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feSECTION 019113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Commissioning Defined:

1. Commissioning (Cx) is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing adjusting and balancing, performance testing and training. Commissioning is intended to achieve the following specific objectives:
  - a. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by the installing contractors.
  - b. Verify and document proper functional performance of equipment and systems.
  - c. Verify that O&M documentation is complete.
  - d. Verify that the Owner's operating personnel are adequately trained.

B. Contractor Responsibilities:

1. This Section and other sections of the specification detail the Contractor's responsibilities relative to the Cx process. It expands on the Cx Plan, which covers the roles and responsibilities of Parties outside of the construction contract.
2. The Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Functional Performance Testing

1.2 RELATED WORK

- A. Section 011100 – Summary of Work
- B. Section 013100 – Project Management and Coordination
- C. Section 013300 – Submittals
- D. Section 017700 – Closeout Procedures
- E. Section 017900 – Demonstration and Training
- F. Section 220800 – Plumbing Commissioning Requirements
- G. Section 230800 – Heating, Ventilating and Air Conditioning Commissioning Requirements
- H. Section 260800 – Electrical Commissioning Requirements

### 1.3 REFERENCE STANDARDS

- A. ASHRAE Standard 202-2013, "The Commissioning Process for Buildings and Systems"
- B. ASHRAE Guideline 4-2008, "Preparation of Operating and Maintenance Documentation for Building Systems"
- C. NEBB - Procedural Standards for Building Systems Commissioning
- D. AABC – National Standards for Total System Balance
- E. USGBC - LEED v4.0 for Building Design and Construction
- F. ABBREVIATIONS AND DEFINITIONS
  - 1. Acceptance Phase: This is the phase of the project when the facility and its systems and equipment are inspected, tested, verified, and documented; and when most of the Functional Performance Testing and final training occurs. This will generally occur after the Construction Phase is complete (after Start-Up Documentation have been completed). The Acceptance Phase begins upon System 'Turn-Over' with certification by the Contractor that the systems have been placed into service in accordance with the approved protocols and after the submission of the approved Start-Up Documentation. The Acceptance Phase ends with the successful completion of all Functional Performance Testing and sign-off by the CxA and Owner.
  - 2. Action Item (AI): Any Cx-related issue that requires a response, completion, corrective or additional work, or any other action. Examples include a Request for Information (RFI), a work directive, a clarification request, a to-do item, an identified deficiency, or any other like item. Action Items must be categorized as appropriate.
  - 3. Action List: This is a list that is maintained and updated by the CxA that includes all Action Items that relate to Cx activities.
  - 4. A/E: General reference to the Architect/Engineer lead-design entity.
  - 5. ASHRAE: American Society of Heating, Refrigerating, and Air Conditioning Engineers.
  - 6. Building Automation System (BAS): The computer-based control or automation system. BAS is used throughout these Sections. Alternate references common in the industry include facility management system, automatic temperature control system, direct digital control system, building management system, building management and control system, digital control system, Energy Management System, Energy Management and Control System or System Control and Data Acquisition (SCADA) System.
  - 7. Checklist Item: An item to inspect to verify proper installation of equipment or systems by the Contractor. Checklist items simply require a 'Yes/No' or 'OK/Not' response. Start-Up Checklist items are one component of the Start-Up Documentation.
  - 8. Commissioning (Cx): The process of ensuring that all building systems perform interactively according to the design intent, that the systems are efficient and cost effective, and that they meet the Owner's operational needs.
  - 9. Commissioning Authority (CxA): The Party retained by the Owner who will oversee and manage the Cx process, develop and stipulate many of the Cx requirements, and ensure and validate that systems and equipment are designed, installed and tested to meet the Owner's requirements.
  - 10. Commissioning Coordinator (CxC): This refers to the Individual within each of the various Parties that is designated the POC for that Party relative to Cx activities. Each of the Contractors subject to the Cx process should designate a CxC and make that person available to the CxA as the point-of-contact for that Contractor.
  - 11. Commissioning Specifications: Generic reference to any of the Cx-specific specification Sections, as inferred by the usage. Divisions 01, 22, 23, 26 and others contain Sections that are specific to or reference the Cx process. All Contractor requirements relating to Cx should be conveyed

- within the Cx Specs. Cx Specs should be referenced but not duplicated within the Cx Plan (the Cx Plan is designed to govern non-Contractor-related Cx issues).
12. Commissioning Team: The group of Parties involved in the Cx process for any given system. The Cx Team will include a core group involved with all systems, consisting of the CxA and CxC members representing the CM and the Owner. On any given system, the Cx Team will additionally include the CxC's for the Contractors responsible for the system or equipment.
  13. Cx Web Tool: is a Web-based Internet hub used to electronically collaborate and coordinate activities throughout the Cx process. The Web-based interface is hosted by the CxA and is accessible by all Parties participating in the Cx program.
  14. Contractor: As used herein, 'Contractor' is a general reference to the installing Party and can therefore refer to the CM, subcontractors, or vendors as inferred by its usage.
  15. Construction Manager (CM): The Party acting as the primary coordinator of all the major subcontractors (MC, EC, TAB, BAC, etc.) as applicable.
  16. Construction Phase: Phase of the project during which the facility is constructed and/or when systems and equipment are installed and started. Contractor and subcontractors complete the installation, complete Start-Up Documentation, submit O&M information, establish trends, and perform any other applicable requirements to make systems operational. Contractor and Vendors may also conduct 'Equipment and Systems Training' events during this phase. The Construction Phase concludes upon completed Start-Up and TAB of systems and equipment.
  17. Contract Documents: The documents governing the responsibilities and relationships between Parties involved in the design and construction of this project including (but not necessarily limited to):
    - a. Agreements/Contracts;
    - b. Construction Plans and Drawings;
    - c. Specifications;
    - d. Addenda;
    - e. Change Orders;
    - f. Commissioning Plan (for reference only)
  18. Construction Documents: Refers generally to the Contract Documents that dictate the details of the installation (all but item a. above).
  19. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents, does not perform properly or is not complying with the design intent.
  20. Design Engineer: Generic reference to the engineer-of-record or a specific engineering discipline as inferred by its usage.
  21. Design Intent Document (DID): Outdated term that is synonymous with Owner's Project Requirements (see below). OPR is now used by both ASHRAE and LEED.
  22. Electrical Contractor (EC): Contractor generally responsible for Division 26 work.
  23. Factory-Authorized Representative: An individual fully trained on the equipment and certified by the manufacturer to perform the respective task.
  24. Factory Testing: Testing of equipment off-site at the manufacturer's facility. May be witnessed by the members of the project team.
  25. Fire Alarm Contractor (FAC): Contractor generally responsible for the fire alarm system installation
  26. Functional Completion: A Cx program milestone that marks the successful completion of the FPTs by the CxA and therefore completion of the Acceptance Phase.
  27. Functional Performance Tests/Testing (FPT): The detailed and thorough tests (and test procedure) developed and performed by the CxA to document proper operation of building systems and the components and equipment making up those systems during the Acceptance Phase. References made to FPT throughout the documents are inclusive of ISFPT unless specifically indicated otherwise.
  28. IAQ: Indoor Air Quality
  29. LEED (Leadership in Energy and Environmental Design): The LEED® Green Building Rating System is a voluntary, consensus-based rating system designed to encourage building owners to

- apply leading proven technologies for new construction. Areas of concentration include “Sustainable Sites”, “Water Efficiency”, Energy and Atmosphere”, “Materials and Resources”, and “Indoor Environmental Quality”. Contractor activities from demolition to procurement to commissioning to waste handling can be impacted by the LEED program.
30. Manufacturer’s Representative: Either an individual in direct employ of the manufacturer of the applicable system, or an individual who is certified by that manufacturer to perform the applicable work for which the reference is made. This is synonymous with Factory-Authorized Representative.
  31. Mechanical Contractor (MC): Contractor generally responsible for Division 23 work.
  32. O&M Documentation: Contractor-developed documentation designed to address the needs of facilities personnel and customized for the context of the specific facility and installation. The foundation of O&M Documentation is manufacturer’s literature (O&M Manuals), with additional Contractor-developed step-by-step instructions for manual start/stop, emergency procedures, operating sequences, preventative maintenance, and other installation-specific information. O&M Documentation content is indexed/organized by equipment-type.
  33. O&M Manuals: Generic reference to manufacturer-published O&M materials, which have no information specific to the facility, but may be edited or marked up to indicate specific equipment or systems installed. O&M Manuals include documents covering installation, operation, maintenance, troubleshooting guides, parts numbers, engineering and design parameters, applications manuals, and any/all information available from the manufacturer pertaining to the installed equipment or systems. Specifications should strive for this information to be submitted in electronic form whenever possible. The electronic versions of these documents can also be electronically edited to indicate equipment installed and to delete or mask-over equipment and content that is not installed on the project.
  34. Opposite Season: The season opposite that when the majority of the testing occurs.
  35. Owner’s Project Requirements (OPR): The OPR is intended to provide the basis from which all design, construction, acceptance, and operational decisions are made. It details the functional requirements of the project, including systems subject to commissioning. The OPR defines the benchmarks and metrics by which the success of the project is ultimately judged, and evolves through each project Phase. The OPR is typically developed early in the project cycle by the Owner and the A/E and provides the user needs, requirements, goals, and metrics that are defined by the Owner to be important. The OPR criteria are referenced by and should be the foundation of the BOD narrative.
  36. Party: Entity (company, corporation, etc.) legally responsible for portion of work.
  37. Point-of-Contact (POC): General reference to a key individual within each Party.
  38. Prefunctional: The term “Prefunctional” is synonymous with “Start-Up”, but not used in these specifications. It is a modifier for checks, tests, and other activities that occur prior to and are prerequisites for Functional Performance Testing.
  39. Project Phases: Phases of the project include the Construction Phase, Acceptance Phase, Warranty Phase, and Occupancy. Earlier Phases include Program Phase and Design Phase.
  40. Project Officer (PO): Individual or entity directly employed by the Owner who is in charge of the design and construction coordination for the project. Alternately, the Owner may employ a separate DM to perform this function.
  41. RFI: Request for Information.
  42. Room Data Sheet: The Room Data Sheet is a spreadsheet or database which lists the control and occupancy requirements - including the temperature and humidity setpoints, pressurization, etc. - for each room or control zone in the facility. This list also includes the control range tolerances and the alarm ranges for the zone. Additionally, the Room Data Sheet may include occupancy schedules or lighting control parameters (typical for vivariums and some laboratories) which must be programmed for initial occupancy. This should be updated through the construction process to reflect any changes generated during construction.
  43. Start-Up: Refers to the quality control procedures whereby the Contractor verifies the proper installation of a device or piece of equipment, executes the manufacturer's starting procedures, completes the ‘Start-Up Checklist’, energizes the device, verifies that it is in proper working order



- and ready for dynamic testing, and completes the ‘Start-Up Tests’. Start-Up procedures are performed by the Contractor with or without a formal Cx process, although the documentation is more formalized when the Cx process is used.
44. **Start-Up Checklist:** A list of items to inspect to verify proper installation of equipment or systems by the Contractor. Checklist items simply require a ‘Yes/No’ or ‘OK/Not’ response. These include primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension checked, oil levels OK, labels affixed, gages in place, sensors calibrated, etc.). Start-Up Checklist items are one component of the Start-Up Documentation (Start-Up Tests being the other).
  45. **Start-Up Documentation:** Refers to the combination of Start-Up Checklists + Start-Up Tests. The Contractor documents the Start-Up procedure by completing and submitting the Start-Up Documentation. Start-Up Documentation may be a combination of procedures prepared by the CxA, those included in the Contractors in-house quality assurance process, and those required by the manufacturer. Regardless of the context of the checklist or format of the form used to documents it, the reference to ‘Start-Up Documentation’ includes all of the stated checklists and tests.
  46. **Start-Up Test:** This is a quality-assurance test that is required to ensure the system is ready to be placed into service. It differs from a checklist item in that it requires more than a binary (yes/no, OK/Not OK) response - an observation, measurement, or sequence of events must be documented. Start-Up Tests are one component of the Start-Up Documentation (Start-Up Checklists being the other).
  47. **System Turn-Over Meeting (“Turn-Over”):** Turn-Over is a quality control milestone in which all Contractors responsible for completing the installation and start-up of a system or equipment, along with the PO and CM, meet to validate that the system or equipment is completed and operational per the contract documents and ready for Functional Performance Testing, and that all the Start-Up Documentation and nameplate data is complete and accurate. The CxA will in many cases participate in this. CM shall organize and lead the process in all cases.
  48. **Systems Matrix:** A table that lists systems and equipment as individual rows (typically using the specifications sections as a guide) and columns that indicate different tasks, documentation, and work elements. The content of the cells of the matrix summarizes the requirement for system as it relates to that column. It provides an effective summary of requirements.
  49. **Test:** A task, procedure or measurement that confirms capacity, functionality, accuracy, etc. Tests have a status of “Pass”, “Fail”, “Couldn’t Test” or “Didn’t Test”. May refer to Start-Up or Functional Performance Tests.
  50. **TAB:** Can refer to the test, adjust, and balance process or the Testing, Adjusting, and Balancing Contractor as inferred by its usage.
  51. **Temporary Conditioning Plan:** A plan that summarizes the logistics, procedures and protocols for taking permanent equipment and using it to maintain conditions throughout construction. All members of the Cx Team must approve the Temporary Conditioning Plan prior to placing equipment into temporary service.
  52. **Testing Agency:** An independent agency typically retained by the Contractor to perform specialized testing of systems or equipment (most commonly electrical). The Testing Agency shall be qualified and equipped to perform the testing and shall submit appropriate qualifications.
  53. **Trending:** Monitoring and recording a history of parameters typically using the building automation system.
  54. **Turn-Over:** See “System Turn-Over Meeting” above.
  55. **Vendor:** Refers to the organization that sold a system or equipment to the subcontractor. This may be a branch office of the manufacturer or a value-added reseller.
  56. **Warranty Period:** The period defined by the construction documents where elements of the facility are under contractual warranty.
  57. **Warranty Phase:** Includes the early occupancy of the building and can continue through the contractual Warranty Period and at least into the opposite season from when the facility systems were initially tested.

#### 1.4 EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

##### A. Mechanical Systems (and all integral equipment controls)

1. Building automation systems, including linkages to remote monitoring and control sites
2. Science room control systems and pressurization
3. Chilled water system, chilled water pumps, piping, and associated equipment
4. Dehumidification systems
5. Heating hot water system, associated pumps, piping, and equipment
6. Preheat and Reheat water systems and associated pumps and piping
7. Air Handling Units, including heat recovery modules
8. Exhaust and other specialty fans
9. Fan Coil Units, Unit Heaters, and Ventilators
10. Variable Air Volume Air terminal units, both supply and exhaust
11. Ductwork
12. Kitchen Exhaust Systems
13. Domestic hot water systems
14. Test, Adjust, and Balance of HVAC air and water systems

##### B. PLUMBING SYSTEMS TO BE COMMISSIONED

1. Domestic hot water systems
2. Natural gas supply equipment
3. Sump pumps and sump pump controls

##### C. Automation Systems

1. All integral automation equipment controls, including building automation systems, laboratory control systems, and linkages to remote monitoring and control sites; to include integrated enterprise management system (EMS) and links to fire protection and alarm systems, plumbing, HVAC systems, electrical systems, communication system, electronic detection and alarm systems, building automation operator workstation graphics, smoke control system, and elevators.

##### D. Electrical Systems

1. Controls and occupancy sensors for Lighting and Day lighting Systems
2. Electrical system from the building entrance through the main switchboard, switchgear, and to the distribution panels.
3. Metering equipment
4. Motor Control Centers, Variable Speed Drives, Motor Starters, protective devices.
5. Building lighting and lighting control – Verify sequence of operations, and luminaries for proper operation, lamping and lighting levels.
6. Emergency power system including generator set, Uninterruptible Power Supply (UPS), transfer switch, fire pump controller interface, associated equipment and testing.

#### 1.5 COMMISSIONING TEAM COORDINATION

- A. Members: The members of the commissioning team consist of the Commissioning Authority (CxA), the OPM, facilities personnel, the CxS, the CM, the MC, the EC, the TAB representative, the SI, the water treatment contractor, the fire protection contractor, and any other installing Subs or suppliers of equipment. In addition, representatives of the A/E team are also commissioning team members and are invited to observe critical procedures and attend Cx coordination meetings.

- B. Management: The CxA is hired by the Owner and directs and coordinates the commissioning activities and reports to the OPM. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Commissioning Sequence: The Cx process will be categorized into Phases as indicated below and defined under the definitions section above. Different systems and/or areas may be in a different phase at any given time in the overall construction process:
  - 1. Construction Phase
  - 2. Acceptance Phase
  - 3. Warranty Period
- D. Scheduling
  - 1. Prior to submission of the baseline schedule, the CM will coordinate with the CxA to specifically include the detailed tasks involved in the Cx process in the master project schedule. CxA shall consult directly with the CM to incorporate the Cx tasks in the project schedule. The process logic and integration shall ultimately be a collaboration between CM, CxA, and subcontractors. The effort will start with CxA and CM proposing initial logic. Then subcontractors will join the discussion and work out the final details, (precedent logic and durations).
  - 2. The Cx schedule will outline generic Cx tasks with prerequisites to each task. Contractor shall incorporate the tasks into schedule as applicable to each system. This will require a detailed track for each system and as such the scheduler must schedule and code by system as well as by area. Contractor shall collaborate with the CxA to determine impacts of project phasing as applicable. Examples of integrated tasks include:
    - a. Contractor preparation of draft Start-Up Documentation;
    - b. Contractor preparation of *Training Plan*;
    - c. Preparation of *O&M Documentation* content
    - d. Testing Agency activities;
    - e. Electrical System Start-Up
    - f. Mechanical System Start-Up (by system – ie: chilled water, hot water, air)
    - g. BAS Start-Up
    - h. Test and Balance (by system – ie: chilled water, hot water, air)
    - i. Training Events (by system – ie: chilled water, hot water, air)
    - j. Functional Performance Testing (by system – ie: chilled water, hot water, air)

#### 1.6 SUBMITTALS

- A. The CM shall provide a list of required equipment/system submittals to the CxA. The CxA will identify submittals to be submitted to the CxA concurrent with submission to the A/E for review.
- B. All Subs, through the CM, shall submit required installation, start-up, and preventive maintenance equipment data sheets to the CxA within 45 days of equipment approval by the A/E.
- C. All Subs, through the CM, shall submit O&M data for system and equipment being commissioned under this specification. O&M data shall be submitted within 45 days of equipment approval by the A/E, but no less than 8 weeks prior to the beginning of functional testing.
- D. The CM shall submit a copy of the construction meeting minutes, updated construction schedule, RFI log, and ASI log to the CxA within seven days of each meeting or update.

## 1.7 COMMISSIONING COORDINATION

A. Coordination responsibilities and management protocols relative to Cx are outlined below. Contractor shall have input in the protocols and all Parties will commit to process and scheduling obligations. The CxA will document and distribute as applicable.

1. Commissioning kick-off meeting: CxA shall schedule and conduct a Cx coordination meeting near the beginning of construction. At a minimum, the following should be discussed at the meeting:
  - a. The commissioning documents (specifications and Cx Plan)
  - b. Requirements and sequence of commissioning
  - c. Responsibilities of the project stakeholders
  - d. Management protocols
  - e. Required submittals
  - f. Schedule
2. Submittals and Shop Drawings: A/E shall distribute these to the CxA. CxA shall edit the project's submittal log to communicate which submittals must be forwarded to CxA.
3. CxA Review Comments on Submittals/Shop Drawings: CxA will review and document comments and a copy will be made available to the A/E by the CxA. A/E shall consider and incorporate at their discretion.
4. Deficiencies Identified by the CxA: When the CxA identifies a deficiency, CxA shall make a good faith assessment of responsible parties. Those parties, as well as CM and Architect shall be notified of the perceived deficiency. This communication is FOR INFORMATION ONLY and is not a directive to any party to resolve the deficiency. Contractor may accept responsibility and resolve the deficiency voluntarily. If Contractor contests either the deficiency or responsibility for that deficiency, Contractor shall respond to that deficiency indicating disagreement. If responsibility is not agreed to via the Cx dialogue, CM shall issue a work directive or RFI via the normal contractual channels to resolve the issue.
5. Requests for Meetings: Request by the Contractor for a meeting with the CxA shall be routed through CM who will then determine the validity. Note that every attempt should be made to deal with Cx issues at regularly scheduled Cx Meetings.
6. Control Sequence Modifications: CxA shall make every attempt to thoroughly review the sequences during the submittal process and address any issues prior to the submittal approval. However, CxA and the contractor may incorporate minor changes to the sequence during testing when it is apparent that it improves the control of the equipment but does not fundamentally change the sequence. The time required by the contractor for this type of modification is addressed in Section 230800. Any and all changes must be thoroughly documented in the contract documents.
7. Scheduling Coordination: CxA shall consult directly with the CM to incorporate the Cx tasks in the project schedule. The process logic and integration shall ultimately be a collaboration between CM, CxA, and subcontractors. The effort will start with CxA and CM proposing initial logic. Then subcontractors will join the discussion and work out the final details, (precedent logic and durations).
8. Notification of Completion Milestones: Contractor shall notify CM at least two weeks prior to an anticipated Cx activity or milestone (such as Turn-Over). CM shall then coordinate the scheduling of the activity (as applicable) between all required parties as applicable. Notification shall be via electronic communication (ie: email) with an associated Action Item distributed to interested parties.
9. Issue Log: CxA maintains a categorized deficiency/issue log which tracks the Cx-related items for corrective action. All content of the deficiency/issue log will be made available to all parties. Contractors with an assigned issue are responsible for making corrections and reporting updates and actions for each assigned item to the CxA via an agreed upon method of communication.
10. Start-Up Checklist and Test Documents: CxA will provide initial 'generic' Start-Up Documents to the Contractor (checklists). The Contractor shall cross check these with the manufacturer-specific start-up procedures/checklists and submit both to the CxA for review and approval. The

Contractor has the option of modifying the supplied generic checklists in the delivered format, or by supplementing the checklists with their own procedures/checklists. The Contractor then executes, signs, and submits the final reviewed and approved Start-Up Documentation. The CxA will review the procedures/checklists for completeness. The Start-Up Documentation is then included in the final commissioning report documents.

11. Functional Performance Test Documents: Functional Performance Tests (FPT) are prepared and completed by the CxA. They are developed during the construction phase, typically after submittal reviews are completed. CxA forwards the FPT procedures to the CM to be subsequently distributed to the Contractors for review. Contractors review and have the option to comment on the procedures. Throughout the Cx process, CxA maintains a current record of the FPTs and their results and keeps the documentation up to date and accessible for all to review progress. CxA may distribute copies of the FPTs at the completion of any significant stage of commissioning.

## PART 2 - PRODUCTS

### 2.1 TEST EQUIPMENT

- A. All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical or controls contractor of Division 23 shall ultimately be responsible for all standard testing equipment for the HVAC system in Division 23. Likewise, the electrical contractor has Division 26, and Plumbing contractor has Division 22
- B. Special equipment, tools, instruments, and setup software (only available from vendor/Subs, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be provided by the Contractor and left on site, for the CxA and the test/adjust/balance (TAB) firm to use during TAB, functional testing, seasonal testing, and deferred testing. The equipment, tools, instruments, and setup software will be returned to the vendor/Subs after successful conclusion of the commissioning effort.
- C. The controls contractor shall provide the CxA with temporary software license to be loaded on the CxA's and/or TAB firm's computer, and any necessary network connection cables, for accessing the direct digital control system field panels for system testing. If applicable, the controls contractor shall also provide a palm device with attachments, software, and cables, to check setpoint values of terminal device controllers. The controls contractor shall provide the CxA with log-on ID and password for remote connection to direct digital control system. All of the software and misc interface appurtenances provided to the CxA will be returned at the successful conclusion of the commissioning effort.
- D. All testing equipment used by the contractors shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified by the Engineer of Record in the Contract Documents. If not otherwise noted, the following minimum requirements shall apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.1°F and a resolution of +/- 0.1°F. Humidity sensors shall have a certified calibration within the past 6 months and a resolution of +/- 1%. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. Accuracy of other sensors shall be at least twice that of the instrumentation being used. All equipment shall be calibrated according to the manufacturer's recommended intervals, in addition to just after being dropped or damaged. Calibration tags shall be affixed or certificates readily available.
- E. Cx WEB-BASED COMMISSIONING TOOL

1. General: A Web-based internet hub used to electronically collaborate and coordinate activities and deliverables throughout the Cx process. The tool is hosted by the CxA and shall be accessible to all parties participating in the Cx program. The tool needs to provide a common location to store Start-Up Documentation, Functional Performance Tests and results, project documents and deliverables. It also serves as a collaborative hub to facilitate, automate, and track communications between parties relating to the Cx process. The Cx web-based tool should have the capability to interface with other web-based database tools that may be used by the Construction Manager or Owner to facilitate the exchange of information.
2. Participation: All general and major subcontractors participating in the Cx process shall participate in the use of the Cx web-based tool in support of the Cx process and file management capabilities.
3. Requirements for Use: Options for accessing and interfacing with the Cx tool are as follows:
  - a. Hardcopy - Print, Test, and File: Using this approach, Contractors simply go online to the Cx interface using a web browser, print checklists and tests as needed, fill them out in the field, and enter the results back into the Cx database when completed.
  - b. Electronically - online in the field: The applicable documents can be accessed and filled out live and online if the Contractor has the means to access the Internet while working in the field using a local Wi-Fi network or wireless air card.
  - c. Optional Database Client: If the Cx interface tool is capable, the CxA can provide the Contractor with an offline software interface tool that will allow the Contractor to download electronic test database files from the interface, work on the database files in the field electronically (but offline), and later synchronize their entries with the master database.
4. Training: The Cx Consultant should include in their contract at least one Contractor training session given by the CxA. Contractors shall send at least one representative to the training session.

## PART 3 - EXECUTION

### 3.1 COMMISSIONING PROCESS

- A. Commissioning during construction begins with a scoping meeting conducted by the CxA where the commissioning process and the draft Cx Plan is reviewed with the commissioning team members. After this meeting, the draft Cx Plan, which is initially provided prior to the scoping meeting, is then updated with the project specific communication protocols, Cx team contact information, and the preliminary commissioning schedule, which is developed during the scoping meeting.
- B. Additional meetings will be conducted as needed throughout construction. These meetings will be scheduled by the OPM, CxA and CM with necessary parties attending. The meetings will be conducted in order to plan, scope, coordinate, schedule future activities and resolve problems. In general, the commissioning meetings will be held monthly during the construction period.
- C. Equipment documentation is submitted to the CxA, concurrent with the normal submittals to the A/E, including detailed pre-startup checklists and startup procedures. Specific submittals requirements are detailed as referenced above, and in section 1.6 above.
- D. The CxA works with the CM and its Subs in developing startup plans and startup documentation formats, including providing the Subs with prefunctional checklists to be completed, during the startup process. The prefunctional checklists are developed by the CxA for the equipment listed in 1.4 above, using the A/E approved submittals.

- E. In general, the checkout and performance verification proceeds from simple to complex, from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.
- F. The CxA will review shop drawings and material certifications, review reports from independent testing agencies, conduct independent on-site periodic construction observation and attend selected quality control-related and construction progress meetings.
- G. The Subs, under their own direction, execute and document the prefunctional checklists and perform startup and initial checkout. The CxA documents that the checklists and startup were completed by the Subs. This will include the CxA witnessing start-up of selected equipment.
- H. The CxA develops specific equipment and system functional performance test procedures. The CxA submits the proposed functional tests to the OPM, A/E and CM for their review and comment, and provides a copy of the proposed functional tests to the responsible Sub who shall review the tests for feasibility, safety and equipment warranty protection.
- I. O&M data is submitted to the CxA prior to execution of functional tests. The CxA reviews the documentation for completeness. The CxA also uses the documentation for reference during the functional testing.
- J. Manufacturers will perform and document all specified Factory Testing and start-up. Copies of test reports are provided to the A/E and CxA for review.
- K. The functional test procedures are executed by the contractor, under the direction of, and documented by the CxA.
- L. Items of non-compliance in material, installation or startup are corrected at the Sub's expense and the system retested.
- M. The CxA reviews, pre-approves and coordinates the training provided by the Subs and verifies that it was satisfactorily completed.
- N. Commissioning is completed before owner occupancy/use.
- O. Deferred testing is conducted, as specified in these specifications.

### 3.2 RESPONSIBILITIES

- A. Construction Manager
  - 1. Shall verify completeness of the building envelope, perimeter and interior items, which affect proper operation and control of equipment and systems.
  - 2. Shall schedule and coordinate participation and cooperation of all subcontractors required for the commissioning process.
  - 3. Shall incorporate commissioning tasks into the master construction schedule.
  - 4. Shall be responsible for providing written responses to the CxA's submittal review comments.
  - 5. Shall provide a Commissioning Supervisor (CxS) who will be responsible for communication between each individual contractor/subcontractor and the CxA. This representative shall be responsible to: coordinate meetings, plan and schedule Cx activities into the project schedule, distribute Cx documentation to responsible contractors, receive written notification from

contractors that Cx issues are corrected, perform corrective actions for resolution of deficiencies, and handle required submittals to the CxA.

6. Review and approve the completion of the PCs, then notify the CxA that functional testing can proceed.
7. Ensure Installing Contractors or their Vendors provide all specialized tools or the use of specialized tools that may be required to start, check-out and functionally test equipment and systems.
8. Shall meet requirements of other commissioning requirements within the Project Manual.
9. Shall schedule and coordinate participation and cooperation of all subcontractors and vendors in owner training.

B. Subcontractors/Suppliers

1. Shall be responsible for providing labor, material, equipment, etc., required within the scope of their specialty to implement and facilitate the commissioning process.
2. Shall include all special tools, software, and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment according to these contract documents in the base bid price to the contractor, except for stand-alone data-logging equipment that may be used by the CxA.
3. Shall demonstrate the operation of the equipment and systems is per the contract documents.
4. Shall assist the CM in the development of the master schedule as relates to commissioning and milestones.
5. Shall respond in writing to written submittal review comments by the CxA.
6. Shall respond in writing as to the completion or resolution of each issue in the commissioning issue log.
7. Shall meet other commissioning requirements within the Project Manual.

C. Owner

1. Schedules the participation of facilities personnel in the commissioning process in writing.
2. Advises the CxA of any changes to the building's use or occupancy.

3.3 MEETINGS

- A. Scoping Meeting: The CxA will schedule, plan, and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CxA within 2 weeks after the meeting. Information gathered from this meeting will allow the CxA to revise the Commissioning Plan to its "final" version.
- B. Commissioning Meetings: Other meetings will be planned and conducted by the CxA as construction progresses. These meetings will cover coordination, deficiency resolution, and planning issues with particular subcontractors.

3.4 START-UP, PRE-FUNCTIONAL CHECKLISTS, AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment and building systems to be commissioned, according to Section 1.4, Systems to be commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified PCs and start-up.
- B. General. Prefunctional checklists are important to ensure that the equipment and systems are completely installed and integrated with other building components and systems, hooked up and operational. It



ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment or assembly receives full Prefunctional checkout. No sampling strategies are used. The Prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of the equipment or subsystems of the given system.

- C. Start-up and Initial Checkout Plan. The CxA shall assist the commissioning team members responsible for start-up of any equipment in developing detailed start-up plans for all equipment. The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for Prefunctional checklists and start-up are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements in Sections 220800, 230800, 260800 and any other sections where test requirements are found.
1. The CxA generates generic and representative Prefunctional checklists and procedures as required in Section 230800. These checklists will indicate required procedures to be executed as part of start-up and initial checkout of the systems and the party responsible for their execution.
  2. These generic checklists and tests are provided by the CxA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each procedure and associated forms may have more than one trade responsible for its execution.
  3. The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CxA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines/fields for recording and documenting the checking and inspections of each procedure and a summary statement with an initial block/ "completed by" associated with each procedure. The responsible party marks the applicable areas in the procedures and makes initial and date lines at each test procedure.
  4. The full start-up plan could consist of something as simple as:
    - a. The CxA's prefunctional checklists.
    - b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
    - c. The manufacturer's normally used field checkout sheets.
  5. The subcontractor submits the full start-up plan to the CxA for review and approval.
  6. The CxA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.
  7. The full start-up procedures and the approval form may be provided to the PM for review and approval, depending on management protocol.

### 3.5 TEMPORARY CONDITIONING

- A. Contractor shall be allowed to utilize permanent building equipment to provide temporary conditioning ONLY upon the approval of the A/E, CM, and the CxA. Approval for such will only be given upon acceptance of a detailed plan provided by the individually involved subcontractors and compiled by the CM. The Temporary Conditioning Plan shall consider/address the following at a minimum:
1. Indicate that the full Start-Up protocol, including development and documentation of Start-Up Documentation as required by the specification will be performed for the temporary start-up. The Temporary Conditioning Plan shall include the Start-Up Documentation to be used, which shall be the same as those that will be used for final Start-Up.
  2. Contractor shall address how equipment will be maintained in good, clean condition. Specifically address:

- a. Temporary Filtering of Air: Air filters used for construction shall be as or more effective than those specified for permanent use. Contractor shall remove construction filters and replace with new filters prior to FPT. Filters shall be maintained and replaced at the specified final pressure drop. Contractor shall install a magnehelic gauge for visual indication of pressure drop as well as setting and adjusting the loaded filter DP switch for monitoring on the BAS.
- b. Temporary Filtering of Water and Condensate: Construction strainers shall be used while circulating fluid during construction. Construction strainer shall be finer than that specified for final strainers.
- c. Sealing/Filtering of Open Ducts: Address that all open ducts shall be either sealed or protected with filter media. Return or exhaust systems shall not be used during construction unless otherwise approved.
- d. Lubrication and Maintenance: Contractor shall maintain the systems and equipment in accordance with the manufacturer's instructions. Contractor shall coordinate lubricants used with CM's operators. Frequency of lubrication and inspection shall be as recommended by manufacturer's literature. Applicable maintenance lubrication schedules shall be included in the Plan. Draft maintenance logs shall be submitted with Plan and completed as maintenance is performed.
- e. Operation Outside of Normal Ranges: Systems and equipment shall not be operated outside the range of specified conditions. The Temporary Conditioning Plan shall address how the Contractor will ensure that operation will not harm the equipment.
- f. Emergency Condition Identification and Response Protocols: The Temporary Conditioning Plan shall address protocols for responding to equipment malfunctions and or harmful operation. Automatic safeties and remote enunciation shall be in place to protect people and property.

### 3.6 FUNCTIONAL PERFORMANCE TESTING

- A. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.
- B. In general, each system shall be operated through all modes of operation where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions shall also be tested. Specific modes required in this project are given in Sections 230800, 260800, and any other sections where test requirements are found.
- C. The CxA shall review Owner-contracted, factory testing or required Owner acceptance tests which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the *Specifications*. Redundancy of testing shall be minimized.
- D. The Subs shall provide sufficient notice to the CxA regarding their completion schedule for the Prefunctional checklists and start-up of all equipment and systems. The CxA will schedule functional tests through the PM, CM, and affected subs. The CxA shall direct, witness and document the functional testing of all equipment and systems. The CxA shall generally execute most standard tests with initial participation of the affected subs.

### 3.7 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Documentation: The CxA will witness and document the results of all functional performance tests using the specific functional checklist forms developed for that purpose. Prior to testing, these forms are provided to the A/E, OPM and Subs for review.
- B. Non-Conformance
  - 1. The CxA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues will be noted and reported to the OPM in writing.
  - 2. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented.
  - 3. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CxA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the OPM. A test shall be aborted if any system deficiency prevents the successful completion of the test or if any participating contractor team member of which participation is specified is not present for the test.
  - 4. As tests progress and a deficiency is identified, the CxA discusses the issue with the executing contractor.
    - a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:
      - 1) The CxA documents the deficiency and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CxA submits the non-compliance reports to the OPM for signature, if required. A copy of the deficiencies is provided to the CM and Subs. The Sub corrects the deficiency, then signs-off that the correction has been made, certifying that the equipment is ready to be retested and sends it back to the CxA.
      - 2) The CxA reschedules the test and the test is repeated.
    - b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
      - 1) The deficiency shall be documented, along with the Sub's response, and a copy given to the OPM, the CM and to the Sub representative assumed to be responsible.
      - 2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the OPM.
      - 3) The CxA documents the resolution process.
      - 4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs-off that the correction is complete, and provides the written sign-off to the CxA. The CxA and CM shall reschedule the test, and the test is repeated.
  - 5. Cost of Retesting
    - a. The cost for the Sub to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs.
    - b. Functional retesting and delays due to contractor's ability to complete work or contractor's inadequate pre-functional testing may be backcharged to the CM at WCPS discretion. CM may choose to recover these costs from the responsible subcontractor.
  - 6. The CM shall respond in writing to the CxA and OPM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
  - 7. Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.
- C. Failure Due to Manufacturer Defect

1. If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CM, the OPM, the A/E, or the CxA. In such case, the responsible Sub shall provide the Owner with the following:
  - a. Within one week of notification from the OPM, the Sub or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the OPM within two weeks of the original notice.
  - b. Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.
  - c. The OPM will determine whether a replacement of all identical units or a repair is acceptable.
  - d. Two examples of the proposed solution shall be installed by the Sub and the OPM will be allowed to test the installations for up to one week, upon which the OPM will decide whether to accept the solution.
  - e. Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.
  - f. The time and expenses for the CxA to direct any retesting, above one retest, required because of an equipment failure, will be backcharged to the CM, who may choose to recover costs from the responsible Sub. An example would be motor failures in series powered terminal induction units. Once all motors have been replaced, prefunctionals checklists completed, and documents submitted that all repairs and corrections have been completed, the CxA will direct one retest. If any failures occur during the retest, the CxA will backcharge the CM for additional testing.
  
- D. Approval: The CxA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CxA, if necessary. The CxA recommends acceptance of each test to the OPM. The OPM gives final approval on each test.

### 3.8 OPERATION AND MAINTENANCE MANUALS

#### A. Standard O&M Manuals.

1. The specific content and format requirements for the standard O&M manuals are detailed in Section 019113. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Special requirements for the TAB contractor and Controls Contractor are found in appropriate Division 23 Sections. Electrical requirements are located in the appropriate Division 26 Sections.
2. A/E Contribution. The A/E will include in the beginning of the O&M manuals a separate section describing the systems including:
  - a. The design intent narrative prepared by the A/E, updated to as-built status by the A/E.
  - b. Simplified professionally drawn single line system diagrams on 8 ½" x 11" or 11" x 17" sheets. These shall include chilled water distribution system, water system, condenser water system, heating system, supply air systems, exhaust systems, and others as designated. These shall show major pieces of equipment such as pumps, heat exchangers, humidifiers, control valves, expansion tanks, coils, service valves, etc.
3. CxA Review and Approval. Prior to substantial completion, the CxA shall review the O&M manuals, documentation and redline as-builds *for systems that were commissioned* and list other

systems documentation that the CxA should review to verify compliance with the *Specifications*. The CxA will communicate deficiencies in the manuals to the PM or A/E, as requested. Upon a successful review of the corrections, the CxA recommends approval and acceptance of these sections of the O&M manuals to the PM or A/E. The CxA also reviews each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated. This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

### 3.9 TRAINING OF OWNER PERSONNEL

- A. The CM shall be responsible for training coordination and scheduling and ultimately for ensuring that training is complete.
- B. Owner will be responsible for overseeing and approving the adequacy of the training of Owner personnel for commissioned equipment.
  - 1. Levels of training modules to be provided:
    - a. I - Overview level: An introductory or entry level of training including general features and overview of a system or equipment with related operation procedures. See Div 1, Section 017900, Training module 4-operations and 2-documentation.
    - b. II - User level: A more in-depth level of training including specific features and functions of a system or equipment, related operation and maintenance, and interaction with other systems and equipment. See Div 1, Section 017900, training module 1-basis of system design, 2-documentation, 3-emergencies, 6-troubleshooting, and 8-repair,
    - c. III - Support level: An advanced level of technical training for maintenance and repair support staff including classroom plus hands-on comprehensive instruction with review of components, schematics, wiring diagrams and functions of a system or equipment, and related service, troubleshooting, repair and recommended spare parts. See Div 1, Section 017900, training module 5-adjustment, 6-troubleshooting, 7-maintenance, and 8-repair.
  - 2. Instructor capabilities shall be commensurate with level of instruction required. Instructor qualifications shall be submitted to Owner and CxA for review prior to training.
  - 3. In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors is specified in Divisions 1, 21, 22, 23, and 26.
  - 4. Each Sub and vendor responsible for training shall submit a written training plan to the Owner and CxA for review and approval prior to training. The plan shall include the following elements:
    - a. Equipment (included in training)
    - b. Intended audience
    - c. Location of training
    - d. Objectives
    - e. Subjects covered (description, duration of discussion, special methods, etc.)
    - f. Duration of training on each subject
    - g. Instructor name and qualifications for each subject
    - h. Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)
  - 5. The Owner shall determine if the training was satisfactorily completed, including attending some of the training, etc.

### 3.10 DEFERRED TESTING

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

- B. Seasonal Testing: During the warranty period, seasonal testing shall be completed as part of this contract. Seasonal testing is intended to test the performance of systems under full load conditions that cannot be simulated during the functional testing period. For example, it is impossible to test the heating system under full load conditions in July, so the heating system would be full load tested during the winter months. The CxA will coordinate this activity. Tests will be executed, documented, and deficiencies corrected by the appropriate Subs, with facilities staff and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing will be made by the CM and its Subs.

END OF SECTION 019113

## SECTION 051213 - ARCHITECTURALLY EXPOSED STRUCTURAL STEEL FRAMING

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Architecturally exposed structural steel (AESS).
2. Section 051200 "Structural Steel Framing" requirements that also apply to AESS.

#### 1.2 DEFINITIONS

- A. AESS: Architecturally exposed structural steel.
- B. Category AESS 2: Structural steel that is categorized by ANSI/AISC 303, Section 10, as AESS 2 and is designated as AESS 2 or Category AESS 2 in the Contract Documents.

#### 1.3 COORDINATION

- A. Coordinate surface preparation requirements for shop-primed items.
- B. Coordinate selection of shop primers with topcoats to be applied over them. Comply with paint and coating manufacturers' written recommendations to ensure that shop primers and topcoats are compatible with one another.

#### 1.4 PREINSTALLATION MEETINGS

- A. Preinstallation Conference: Conduct conference at Project site.

#### 1.5 ACTION SUBMITTALS

A. Product Data:

1. Tension-control, high-strength, bolt-nut-washer assemblies.
2. Corrosion-resisting (weathering steel), tension-control, high-strength, bolt-nut-washer assemblies.
3. Filler.
4. Primer.
5. Galvanized-steel primer.
6. Etching cleaner.
7. Galvanized repair paint.

- B. Shop Drawings: Show fabrication of AESS components. Shop Drawings for structural steel may be used for AESS.

1. Identify AESS category for each steel member and connection, including transitions between AESS categories and between AESS and non-AESS.
2. Include details of cuts, connections, splices, camber, holes, and other pertinent data.
3. Include embedment Drawings.
4. Indicate orientation of mill marks and HSS seams.
5. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld. Show backing bars that are to be removed and supplemental fillet welds where backing bars are to remain. Indicate grinding, finish, and profile of welds.
6. Indicate type, size, and length of bolts, distinguishing between shop and field bolts. Identify pretensioned and slip-critical, high-strength bolted connections. Indicate orientation and location of bolt heads.
7. Indicate exposed surfaces and edges and surface preparation being used.
8. Indicate special tolerances and erection requirements.
9. Indicate weep holes for HSS and vent holes for galvanized HSS.
10. Indicate surface preparation, primer, and coating requirements, including systems specified in other Sections.

C. Samples: Submit Samples to set quality standards for AESS.

1. Two steel plates, 3/8 by 8 by 4 inches, with long edges joined by a groove weld and with weld ground smooth.
2. Steel plate, 3/8 by 8 by 8 inches, with one end of a short length of rectangular steel tube, 4 by 6 by 3/8 inches, welded to plate with a continuous fillet weld and with weld ground smooth and blended.
3. Round steel tube or pipe, minimum 8 inches in diameter, with end of another round steel tube or pipe, approximately 4 inches in diameter, welded to its side at a 45-degree angle with a continuous fillet weld and with weld ground smooth and blended.

## 1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer and fabricator.
- B. Paint Compatibility Certificates: From manufacturers of topcoats applied over shop primers, certifying that shop primers are compatible with topcoats.

## 1.7 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified Installer who participates in the AISC Quality Certification Program, is designated an AISC-Certified Erector, Category ACSE, and is experienced in erecting AESS similar to that indicated on this Project.
- B. Shop-Painting Applicators: Qualified according to AISC's Sophisticated Paint Endorsement P1 or SSPC-QP 3.
- C. Mockups: Build mockups of AESS to set quality standards for fabrication and installation.
  1. Build mockup of typical portion of AESS as shown on Drawings.



2. Coordinate painting requirements with Section 099113 "Exterior Painting." Section 099123 "Interior Painting."
3. Coordinate high-performance coatings requirements with Section 099600 "High-Performance Coatings."

#### 1.8 DELIVERY, STORAGE, AND HANDLING

- A. Use special care in handling AESS to prevent twisting, warping, nicking, and other damage during fabrication, delivery, and erection. Store materials to permit easy access for inspection and identification. Keep AESS members off ground and spaced by using pallets, dunnage, or other supports and spacers. Protect AESS members and packaged materials from corrosion and deterioration.
  1. Do not store AESS materials on structure in a manner that might cause distortion, damage, or overload to members or supporting structures. Repair or replace damaged materials or structures as directed.

#### 1.9 FIELD CONDITIONS

- A. Field Measurements: Where AESS is indicated to fit against other construction, verify actual dimensions by field measurements before fabrication.

### PART 2 - PRODUCTS

#### 2.1 PERFORMANCE REQUIREMENTS

- A. Comply with requirements of ANSI/AISC 303, Sections 1 through 9 and as modified in Section 10, "Architecturally Exposed Structural Steel."

#### 2.2 FILLER

- A. Polyester filler intended for use in repairing dents in automobile bodies.

#### 2.3 PRIMER

- A. Steel Primer:
  1. Comply with Section 099113 "Exterior Painting" and Section 099123 "Interior Painting." Section 099113 "Exterior Painting," Section 099123 "Interior Painting," and Section 099600 "High-Performance Coatings."
  2. SSPC-Paint 23, latex primer.
  3. Fabricator's standard lead- and chromate-free, nonasphaltic, rust-inhibiting primer complying with MPI#79 and compatible with topcoat.
- B. Galvanized-Steel Primer: MPI#26.

1. Etching Cleaner: MPI#25, for galvanized steel.
2. Galvanizing Repair Paint: ASTM A780/A780M.

## 2.4 FABRICATION

- A. Shop fabricate and assemble AESS to the maximum extent possible. Locate field joints at concealed locations if possible. Detail assemblies to minimize handling and to expedite erection.
  1. Use special care handling and fabricating AESS before and after shop painting to minimize damage to shop finish.
- B. Category AESS 2:
  1. Comply with overall profile dimensions of AWS D1.1/D1.1M for welded built-up members. Keep appearance and quality of welds consistent. Maintain true alignment of members without warp exceeding specified tolerances.
  2. Prepare surfaces according to Part 2 "Shop Priming" Article and SSPC-SP 6 (WAB)/NACE WAB-3.
  3. Grind sheared, punched, and flame-cut edges to remove burrs and provide smooth surfaces and eased edges.
  4. Make intermittent welds appear continuous, using filler or additional welding.
  5. Seal weld open ends of hollow structural sections with 3/8-inch closure plates.
  6. Limit butt and plug weld projections to 1/16 inch.
  7. Install bolt heads on the same side of each connection and maintain orientation consistently from one connection to another.
  8. Remove weld spatter, slivers, and similar surface discontinuities.
  9. Remove blemishes and surface irregularities resulting from temporary braces or fixtures by filling or grinding, before cleaning, treating, and shop priming.
  10. Grind tack welds smooth unless incorporated into final welds.
  11. Remove backing and runoff tabs, and grind welds smooth.
  12. Limit as-fabricated straightness tolerance to one-half that permitted for structural-steel materials in ANSI/AISC 303.
  13. Limit as-fabricated curved structural steel tolerance to that permitted for structural-steel materials in ANSI/AISC 303.
  14. Limit as-fabricated straightness tolerance of welded built-up members to one-half that permitted by AWS D1.1/D1.1M.
  15. Conceal fabrication and erection markings from view in the completed structure.
  16. Make welds uniform and smooth.
- C. Erection marks, painted marks, and other marks are permitted on galvanized- steel surfaces of completed structure.
- D. Cleaning Corrosion-Resisting (Weathering) AESS: Clean and prepare steel surfaces that are to remain unpainted according to SSPC-SP 6 (WAB)/NACE WAB-3.

## 2.5 SHOP CONNECTIONS

- A. High-Strength Bolts: Shop install high-strength bolts according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for type of bolt and type of joint specified.
  - 1. Joint Type: Snug tightened.
- B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

## 2.6 GALVANIZING

- A. Hot-Dip Galvanized Finish: Apply zinc coating by the hot-dip process to structural steel according to ASTM A123/A123M.
  - 1. Do not quench or apply post-galvanizing treatments that might interfere with paint adhesion.
  - 2. Fill vent and drain holes that are exposed in the finished Work, unless indicated to remain as weep holes, by plugging with zinc solder and filing off smooth.
  - 3. Galvanize AESS attached to structural-steel frame and located in exterior walls.

## 2.7 SHOP PRIMING

- A. Shop prime steel surfaces, except the following:
  - 1. Surfaces embedded in concrete or mortar. Extend priming of partially embedded members to a depth of 2 inches.
  - 2. Surfaces to be field welded.
  - 3. Surfaces to be high-strength bolted with slip-critical connections.
  - 4. Corrosion-resisting (weathering) steel surfaces.
  - 5. Galvanized surfaces unless indicated to be painted.
- B. Surface Preparation: Clean nongalvanized surfaces to be painted. Remove loose rust and mill scale and spatter, slag, or flux deposits. Prepare surfaces according to the following specifications and standards:
  - 1. SSPC-SP 2.
  - 2. SSPC-SP 3.
  - 3. SSPC-SP 7 (WAB)/NACE WAB-4.
  - 4. .
  - 5. SSPC-SP 5 (WAB)/NACE WAB-1.
  - 6.
- C. Preparing Galvanized Steel for Shop Priming: After galvanizing, thoroughly clean steel of grease, dirt, oil, flux, and other foreign matter, and treat with etching cleaner.
- D. Priming: Immediately after surface preparation, apply primer according to manufacturer's written instructions and at rate recommended by SSPC to provide a minimum dry film thickness

of 1.5 mils. Use priming methods that result in full coverage of joints, corners, edges, and exposed surfaces.

1. Stripe paint corners, crevices, bolts, welds, and eased edges.
2. Apply two coats of shop paint to surfaces that are inaccessible after assembly or erection. Change color of second coat to distinguish it from first.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Verify, with steel erector present, elevations of concrete- and masonry-bearing surfaces and locations of anchor rods, bearing plates, and other embedments for compliance with requirements.
  1. Prepare a certified survey of bearing surfaces, anchor rods, bearing plates, and other embedments, showing dimensions, locations, angles, and elevations.
- B. Examine AESS for twists, kinks, warping, gouges, and other imperfections before erecting.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

- A. Provide temporary shores, guys, braces, and other supports during erection to keep AESS secure, plumb, and in alignment against temporary construction loads and loads equal in intensity to design loads. Remove temporary supports when permanent structural steel, connections, and bracing are in place unless otherwise indicated.

### 3.3 ERECTION

- A. Take special care during erection to avoid marking or distorting the AESS and to minimize damage to shop painting. Set AESS accurately in locations and to elevations indicated and according to ANSI/AISC 303 and ANSI/AISC 360.
  1. Remove welded tabs that were used for attaching temporary bracing and safety cabling and that are exposed to view in the completed Work. Take care to avoid any blemishes, holes, or unsightly surfaces resulting from the use or removal of temporary elements.
  2. Grind tack welds smooth.
  3. Remove backing and runoff tabs, and grind welds smooth.
  4. Orient bolt heads on the same side of each connection and maintain orientation consistently from one connection to another.
  5. Remove erection bolts in AESS, fill holes with weld metal or filler, and grind or sand smooth to achieve surface quality approved by Architect.
  6. Fill weld access holes in AESS with weld metal or filler and grind, or sand smooth to achieve surface quality as approved by Architect.
  7. Conceal fabrication and erection markings from view in the completed structure.

B. In addition to ANSI/AISC 303, Section 10 requirements, comply with the following.

1. Erection of Category AESS 1 and Category AESS 2:

- a. Erect AESS to the standard frame tolerances specified in ANSI/AISC 303 for non-AESS.
- b. Comply with AWS D1.1/D1.1M. Keep appearance and quality of welds consistent. Maintain true alignment of members without warp exceeding specified tolerances.
- c. Remove weld spatter, slivers, and similar surface discontinuities.
- d. Grind off butt and plug weld projections larger than 1/16 inch.
- e. Continuous welds are to be of uniform size and profile.
- f. Ream holes that must be enlarged. Use of drift pins or burning is not permitted. Replace misaligned connection plates where holes cannot be aligned with acceptable appearance.
- g. Splice members only where indicated on Drawings.
- h. No torch cutting or field fabrication is permitted.

2. Erection of Category AESS 3:

### 3.4 FIELD CONNECTIONS

A. High-Strength Bolts: Install high-strength bolts according to RCSC's "Specification for Structural Joints Using High-Strength Bolts" for type of bolt and type of joint specified.

1. Joint Type: Snug tightened.

B. Weld Connections: Comply with AWS D1.1/D1.1M for tolerances, appearances, welding procedure specifications, weld quality, and methods used in correcting welding work.

### 3.5 REPAIR

A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas, and touchup galvanizing to comply with ASTM A780/A780M.

B. Touchup Painting:

1. Immediately after erection, clean field welds, bolted connections, and abraded areas of shop paint, and paint exposed areas with the same material as used for shop painting, to comply with SSPC-PA 1 for touching up shop-painted surfaces.

a. Clean and prepare surfaces by SSPC-SP 2 hand-tool cleaning or SSPC-SP 3 power-tool cleaning.

2. Cleaning and touchup painting are specified in Section 099113 "Exterior Painting." Section 099123 "Interior Painting."

C. Touchup Priming: Cleaning and touchup priming are specified in Section 099600 "High-Performance Coatings."

3.6 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to inspect AECS as specified in Section 051200 "Structural Steel Framing." The testing agency is not responsible for enforcing requirements relating to aesthetic effect.
- B. Architect will observe AECS in place to determine acceptability relating to aesthetic effect.

END OF SECTION 051213

## SECTION 084113 - ALUMINUM-FRAMED ENTRANCES AND STOREFRONTS

### PART 1 - GENERAL

#### 1.1 SUMMARY

A. Section Includes:

1. Aluminum-framed entrance and storefront systems.
2. Aluminum sun shades.

B. Related Requirements:

1. Section 079200 "Joint Sealants"
2. Section 088000 "Glazing"
3. Section 087100 "Door Hardware"
4. Section 089119 "Fixed Louvers"

#### 1.2 COORDINATION

- A. A Shop Drawing Coordination Meeting shall be held before door, door frame, and door hardware shop drawings are submitted. The purpose of this meeting will be to coordinate doors, frames, door hardware, and electrical rough-ins. The Contractor shall notify the owner, designer, and affected subcontractors, and schedule the meeting. The Electrical Contractor shall prepare conduit and box rough-in drawings for each door/frame requiring electronic systems or other wiring and bring these drawings to the coordination meeting. The affected trades shall coordinate wiring, rough-ins, door opening construction, door frame and door hardware installation prior to the submission of door shop drawings or electrical rough-in.

#### 1.3 ACTION SUBMITTALS

A. Product Data:

1. Aluminum-framed entrance and storefront systems.
2. Aluminum sun shades

B. Product Data Submittals: For each product.

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories.

C. Shop Drawings:

1. Plans, elevations, sections, full-size details, and attachments to other work.

2. Details of provisions for assembly expansion and contraction and for draining moisture occurring within the assembly to the exterior.
  3. Full-size isometric details of each type of vertical-to-horizontal intersection of aluminum-framed entrance and storefront systems, showing the following:
    - a. Joinery, including concealed welds.
    - b. Anchorage.
    - c. Expansion provisions.
    - d. Glazing.
    - e. Flashing and drainage.
  4. Connection to and continuity with adjacent thermal, weather, air, and vapor barriers.
  5. Plans, sections, and details of sun shade systems, including profiles, anchorage and fasteners, and accessories.
  6. Point-to-point wiring diagrams showing the following:
    - a. Power requirements for each electrically operated door hardware.
    - b. Location and types of switches, signal device, conduit sizes, and number and size of wires.
- D. Samples for Initial Selection: Manufacturer's standard color sheets, showing full range of available colors for each type of exposed finish.
- E. Entrance Door Hardware Schedule: Prepared by or under supervision of supplier, detailing fabrication and assembly of entrance door hardware, as well as procedures and diagrams. Coordinate final entrance door hardware schedule with doors, frames, and related work to ensure proper size, thickness, hand, function, and finish of entrance door hardware.
- F. Delegated Design Submittals: For aluminum-framed entrances and storefront systems and sunshade systems, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Energy Performance Certificates: For aluminum-framed entrance and storefront systems, accessories, and components, from manufacturer.
1. Basis for Certification: NFRC-certified energy performance values for each aluminum-framed entrance and storefront system.
- B. Product Test Reports: For aluminum-framed entrance and storefront systems, for tests performed by a qualified testing agency.
- C. Preconstruction Test Reports: For aluminum-framed entrance and storefront systems.
1. Test Reports: Prepared by a qualified preconstruction testing agency for each preconstruction test.
- D. Source Quality-Control Reports: For aluminum-framed entrance and storefront systems.



- E. Field Quality-Control Reports: For aluminum-framed entrance and storefront systems.
- F. Quality-Control Program: Developed specifically for Project, including fabrication and installation, in accordance with recommendations in ASTM C1401. Include periodic quality-control reports.
- G. Qualification Statements:
  - 1. For Installer.
- H. Delegated Design Engineer Qualifications: For aluminum-framed entrance and storefront systems.
- I. Sample Warranties: For aluminum-framed entrance and storefront systems.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For aluminum-framed entrance and storefront systems.
- B. Maintenance Data for Structural Sealant: For structural-sealant-glazed storefront. Include ASTM C1401 recommendations for post-installation-phase quality-control program.

#### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications:
  - 1. Fabricator of products.
  - 2. Entity that employs installers and supervisors who are trained and approved by manufacturer.
  - 3. Authorized representative who is trained and approved by manufacturer.
  - 4. Entity that is certified under the North American Contractor Certification Program (NACC) and that employs installers and supervisors who are trained and approved by manufacturer.
- B. Delegated Design Engineer Qualifications: A professional engineer who is legally qualified to practice in state where Project is located and who is experienced in providing engineering services of the type indicated.
- C. Laboratory Mockup Testing Agency Qualifications: Qualified in accordance with ASTM E699 for testing indicated.
- D. Testing Agency Qualifications: Qualified in accordance with ASTM E699 for testing indicated and acceptable to Owner and Architect.
- E. Product Options: Information on Drawings and in Specifications establishes requirements for aesthetic effects and performance characteristics of assemblies. Aesthetic effects are indicated by dimensions, arrangements, alignment, and profiles of components and assemblies as they relate to sightlines, to one another, and to adjoining construction.

1. Do not change intended aesthetic effects, as judged solely by Architect, except with Architect's approval. If changes are proposed, submit comprehensive explanatory data to Architect for review.
- F. Structural-Sealant Glazing: Comply with ASTM C1401 for design and installation of storefront systems that include structural glazing.

#### 1.7 MOCKUPS

- A. Build mockups to demonstrate aesthetic effects and to set quality standards for fabrication and installation.
1. Build mockup as one complete storefront frame with glass and sun shade system, including adjacent exterior wall finishes and sealants installed. Architect shall review and approve before additional storefront and sun shades will be installed.
  2. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Owner specifically approves such deviations by Change Order.
  3. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

#### 1.8 WARRANTY

- A. Special Warranty: Manufacturer and Installer agree to repair or replace components of aluminum-framed entrance and storefront systems that fail in materials or workmanship within specified warranty period.
1. Failures include, but are not limited to, the following:
    - a. Structural failures, including but not limited to excessive deflection.
    - b. Noise or vibration created by wind, thermal, and/or structural movements
    - c. Faulty operation of doors, hardware, or other operating components
    - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering and use.
    - e. Water penetration at glazed areas
  2. Warranty Period: 10 years from date of Substantial Completion.
- B. Special Finish Warranty, Factory-Applied Finishes: Standard form in which manufacturer agrees to repair finishes or replace aluminum that shows evidence of deterioration of factory-applied finishes within specified warranty period.
1. Deterioration includes, but is not limited to, the following:
    - a. Color fading more than 5 Delta E units when tested in accordance with ASTM D2244.
    - b. Chalking in excess of a No. 8 rating when tested in accordance with ASTM D4214.
    - c. Cracking, checking, peeling, or failure of paint to adhere to bare metal.

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

## PART 2 - PRODUCTS

### 2.1 SOURCE LIMITATIONS

- A. Obtain all components of aluminum-framed entrance and storefront system, including framing and accessories and sun shade systems, from single manufacturer.

### 2.2 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Engage a qualified professional engineer, as defined in Section 014000 "Quality Requirements," to design aluminum-framed entrance and storefront systems and sun shade systems.
- B. General Performance: Comply with performance requirements specified, as determined by testing of aluminum-framed entrance and storefront systems representing those indicated for this Project without failure due to defective manufacture, fabrication, installation, or other defects in construction.
  1. Aluminum-framed entrance and storefront systems and sun shade systems to withstand movements of supporting structure, including, but not limited to, twist, column shortening, long-term creep, and deflection from uniformly distributed and concentrated live loads.
  2. Failure also includes the following:
    - a. Thermal stresses transferring to building structure.
    - b. Glass breakage.
    - c. Noise or vibration created by wind and thermal and structural movements.
    - d. Loosening or weakening of fasteners, attachments, and other components.
    - e. Failure of operating units.
- C. Structural Loads:
  1. Wind Loads: As indicated on Drawings.
  2. Other Design Loads: As indicated on Drawings.
- D. Deflection of Framing Members Supporting Glass: At design wind load, as follows:
  1. Deflection Normal to Wall Plane: Limited to 1/175 of clear span for spans of up to **13 feet 6 inches (4.1 m)** and to 1/240 of clear span plus **1/4 inch (6.35 mm)** for spans greater than **13 feet 6 inches (4.1 m)**.
  2. Deflection Parallel to Glazing Plane: Limited to amount not exceeding that which reduces glazing bite to less than 75 percent of design dimension and that which reduces edge clearance between framing members and glazing or other fixed components to less than **1/8 inch (3.2 mm)**.
- E. Structural: Test in accordance with ASTM E330/E330M as follows:

1. When tested at positive and negative wind-load design pressures, storefront assemblies, including entrance doors, do not evidence deflection exceeding specified limits.
  2. When tested at 150 percent of positive and negative wind-load design pressures, storefront assemblies, including entrance doors and anchorage, do not evidence material failures, structural distress, or permanent deformation of main framing members exceeding 0.2 percent of span.
  3. Test Durations: As required by design wind velocity, but not less than 10 seconds.
- F. Water Penetration under Static Pressure: Test in accordance with ASTM E331 as follows:
1. No evidence of water penetration through fixed glazing and framing areas, including entrance doors, when tested in accordance with a minimum static-air-pressure differential of 20 percent of positive wind-load design pressure, but not less than **6.24 lbf/sq. ft. (300 Pa)**.
- G. Energy Performance: Certified and labeled by manufacturer for energy performance as follows:
1. Thermal Transmittance (U-factor):
    - a. Fixed Glazing and Framing Areas: U-factor for the system of not more than **0.36 Btu/sq. ft. x h x deg F (2.33 W/sq. m x K)** as determined in accordance with NFRC 100.
    - b. Entrance Doors: U-factor of not more than **0.63 Btu/sq. ft. x h x deg F (3.86 W/sq. m x K)** as determined in accordance with NFRC 100.
  2. Solar Heat-Gain Coefficient (SHGC):
    - a. Fixed Glazing and Framing Areas: SHGC for the system of not more than 0.35 as determined in accordance with NFRC 200.
    - b. Entrance Doors: SHGC of not more than 0.33 as determined in accordance with NFRC 200.
  3. Air Leakage:
    - a. Fixed Glazing and Framing Areas: Air leakage for the system of not more than **0.06 cfm/sq. ft. (0.30 L/s per sq. m)** at a static-air-pressure differential of **1.57 lbf/sq. ft. (75 Pa)** when tested in accordance with ASTM E283.
    - b. Entrance Doors: Air leakage of not more than **1.0 cfm/sq. ft. (5.08 L/s per sq. m)** at a static-air-pressure differential of **1.57 lbf/sq. ft. (75 Pa)**.
- H. Thermal Movements: Allow for thermal movements resulting from ambient and surface temperature changes.
1. Temperature Change: **120 deg F (67 deg C)**, ambient; **180 deg F (100 deg C)**, material surfaces.
  2. Thermal Cycling: No buckling; stress on glass; sealant failure; excess stress on framing, anchors, and fasteners; or reduction of performance when tested in accordance with AAMA 501.5.
    - a. High Exterior Ambient-Air Temperature: That which produces an exterior metal-surface temperature of **180 deg F (82 deg C)**.

- b. Low Exterior Ambient-Air Temperature: 0 deg F (minus 18 deg C).
- c. Interior Ambient-Air Temperature: 75 deg F (24 deg C).

## 2.3 ALUMINUM-FRAMED ENTRANCE AND STOREFRONT SYSTEMS

- A. Basis of Design system for exterior applications: YKK AP America YES 45 TU center-set storefront system. Other acceptable manufacturers, **provided they meet all requirements of this section**, include:
  - 1. Kawneer North America
  - 2. Oldcastle Building Envelope
  - 3. **Tubelite USA**
- B. Framing Members: Manufacturer's extruded- or formed-aluminum framing members of thickness required and reinforced as required to support imposed loads.
  - 1. Exterior Framing Construction: Thermally broken.
  - 2. Interior Vestibule Framing Construction: Nonthermal system acceptable, must be center-set glazing to match exterior system.
  - 3. Glazing System: Retained mechanically with gaskets on four sides.
  - 4. Glazing Plane: Center.
  - 5. Finish: High-performance organic finish.
  - 6. Fabrication Method: Field-fabricated stick system.
  - 7. Aluminum: Alloy and temper recommended by manufacturer for type of use and finish indicated.
  - 8. Steel Reinforcement: As required by manufacturer.
- C. Backer Plates: Manufacturer's standard, continuous backer plates for framing members, if not integral, where framing abuts adjacent construction to provide continuous plane for backer rod and sealant. Vertical mullions to have aluminum end caps to maintain continuous plane.
- D. Brackets and Reinforcements: Manufacturer's standard high-strength aluminum with nonstaining, nonferrous shims for aligning system components.
- E. Sun Shade System: Outrigger based system, anchored to vertical storefront mullions. Exposed fasteners and thermally improved pocket installation. Provide any necessary backers or support in vertical mullions as required for attachment and support of sun shade system. **Finish shall match storefront to which sun shades are attached.** Physically separate all dissimilar metals. Provide 90 degree continuous corners as indicated in Drawings. Refer to Drawings for:
  - 1. Outrigger projection distance.
  - 2. Profile shape of fascias, louvers, and outriggers.
  - 3. Locations and installation heights.
- F. Entrance Doors: Manufacturer's standard glazed entrance doors for manual-swing or automatic operation.
  - 1. Door Construction: ~~1-3/4-inch (44.5-mm) overall thickness, with minimum 0.125-inch (3.2-mm)~~ **2- to 2-1/4-inch (50.8- to 57.2-mm) overall thickness, with minimum 0.125-inch (3.2-mm-)** thick, extruded-aluminum tubular rail and stile members. Mechanically fasten corners with reinforcing brackets that are deeply penetrated and fillet welded or that incorporate concealed tie rods.

- a. Thermal Construction: High-performance plastic connectors separate aluminum members exposed to the exterior from members exposed to the interior.
2. Door Design: Wide stile; 5-inch (127-mm) nominal width.
3. Glazing Stops and Gaskets: Beveled, snap-on, extruded-aluminum stops and preformed gaskets.
  - a. Provide nonremovable glazing stops on outside of door.
4. Finish: Match adjacent storefront framing finish.

## 2.4 ENTRANCE DOOR HARDWARE

- A. Entrance Door Hardware: Hardware not specified in this Section is specified in Section 087100 "Door Hardware" and Section 087111 "Door Hardware Sets."
- B. General: Provide entrance door hardware indicated in this section for each entrance door, to comply with requirements in this Section.
  1. Entrance Door Hardware: Provide quantity, item, size, finish or color indicated, and products complying with BHMA standard referenced.
  2. Sequence of Operation: Provide electrified door hardware function, sequence of operation, and interface with other building control systems indicated.
  3. Opening-Force Requirements:
    - a. Egress Doors: Not more than 15 lbf (67 N) to release the latch and not more than 30 lbf (133 N) to set the door in motion.
    - b. Accessible Interior Doors: Not more than 5 lbf (22.2 N) to fully open door.
- C. Strikes: Provide strike with black-plastic dust box for each latch or lock bolt; fabricated for aluminum framing.
- D. Weather Stripping: Manufacturer's standard replaceable components.
  1. Compression Type: Made of ASTM D2000 molded neoprene or ASTM D2287 molded PVC.
  2. Sliding Type: AAMA 701/702, made of wool, polypropylene, or nylon woven pile with nylon-fabric or aluminum-strip backing.
- E. Weather Sweeps: Manufacturer's standard exterior-door bottom sweep with concealed fasteners on mounting strip.

## 2.5 GLAZING

- A. Glazing: Comply with Section 088000 "Glazing."
- B. Provide louvers in lieu of glass where indicated on Drawings. Refer to Section 089119 "Fixed Louvers" for more information.

- C. Glazing Gaskets: Manufacturer's standard sealed-corner pressure-glazing system of black, resilient elastomeric glazing gaskets, setting blocks, and shims or spacers.
- D. Glazing Sealants: As recommended by manufacturer.

## 2.6 MATERIALS

- A. Sheet and Plate: **ASTM B209** (**ASTM B209M**).
- B. Extruded Bars, Rods, Profiles, and Tubes: **ASTM B221** (**ASTM B221M**).
- C. Structural Profiles: ASTM B308/B308M.
- D. Steel Reinforcement:
  - 1. Structural Shapes, Plates, and Bars: ASTM A36/A36M.
  - 2. Cold-Rolled Sheet and Strip: ASTM A1008/A1008M.
  - 3. Hot-Rolled Sheet and Strip: ASTM A1011/A1011M.
- E. Steel Reinforcement Primer: Manufacturer's standard zinc-rich, corrosion-resistant primer complying with SSPC-PS Guide No. 12.00; applied immediately after surface preparation and pretreatment. Select surface preparation methods in accordance with recommendations in SSPC-SP COM, and prepare surfaces in accordance with applicable SSPC standard.

## 2.7 ACCESSORIES

- A. Fasteners and Accessories: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding fasteners and accessories compatible with adjacent materials.
  - 1. Use self-locking devices where fasteners are subject to loosening or turning out from thermal and structural movements, wind loads, or vibration.
  - 2. Reinforce members as required to receive fastener threads.
  - 3. Use exposed fasteners with countersunk Phillips screw heads, finished to match framing system.
- B. Anchors: Three-way adjustable anchors with minimum adjustment of **1 inch (25.4 mm)** that accommodate fabrication and installation tolerances in material and finish compatible with adjoining materials and recommended by manufacturer.
  - 1. Concrete and Masonry Inserts: Hot-dip galvanized cast-iron, malleable-iron, or steel inserts complying with ASTM A123/A123M or ASTM A153/A153M requirements.
- C. Concealed Flashing: Manufacturer's standard corrosion-resistant, nonstaining, nonbleeding flashing compatible with adjacent materials.
- D. Bituminous Paint: Cold-applied asphalt-mastic paint containing no asbestos, formulated for **30-mil (0.762-mm)** thickness per coat.
- E. Rigid PVC filler.

## 2.8 FABRICATION

- A. Form or extrude aluminum shapes before finishing.
- B. Weld in concealed locations to greatest extent possible to minimize distortion or discoloration of finish. Remove weld spatter and welding oxides from exposed surfaces by descaling or grinding.
- C. Fabricate components that, when assembled, have the following characteristics:
  - 1. Profiles that are sharp, straight, and free of defects or deformations.
  - 2. Accurately fitted joints with ends coped or mitered.
  - 3. Physical and thermal isolation of glazing from framing members.
  - 4. Accommodations for thermal and mechanical movements of glazing and framing to maintain required glazing edge clearances.
  - 5. Fasteners, anchors, and connection devices that are concealed from view to greatest extent possible.
- D. Mechanically Glazed Framing Members: Fabricate for flush glazing without projecting stops.
- E. Storefront Framing: Fabricate components for assembly using shear-block system or screw-spline system.
- F. Entrance Door Frames: Reinforce as required to support loads imposed by door operation and for installing entrance door hardware.
  - 1. At interior and exterior doors, provide compression weather stripping at fixed stops.
- G. Entrance Doors: Reinforce doors as required for installing entrance door hardware.
  - 1. At pairs of exterior doors, provide sliding-type weather stripping retained in adjustable strip and mortised into door edge.
  - 2. At exterior doors, provide weather sweeps applied to door bottoms.
- H. Entrance Door Hardware Installation: Factory install entrance door hardware to the greatest extent possible. Cut, drill, and tap for factory-installed entrance door hardware before applying finishes.
- I. After fabrication, clearly mark components to identify their locations in Project in accordance with Shop Drawings.

## 2.9 ALUMINUM FINISHES

- A. High-Performance Organic Finish, Two-Coat PVDF: Fluoropolymer finish complying with AAMA 2605 and containing not less than 70 percent PVDF resin by weight in color coat.
  - 1. Prepare, pretreat, and apply coating to exposed metal surfaces to comply with coating and resin manufacturers' written instructions.
  - 2. Color and Gloss: As selected by Architect from manufacturer's full range.



## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine areas, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 INSTALLATION OF ALUMINUM-FRAMED ENTRANCE AND STOREFRONT SYSTEMS

- A. Comply with manufacturer's written instructions.
- B. Do not install damaged components.
- C. Fit joints to produce hairline joints free of burrs and distortion.
- D. Rigidly secure nonmovement joints.
- E. Install anchors with separators and isolators to prevent metal corrosion and electrolytic deterioration and to prevent impeding movement of moving joints.
- F. Seal perimeter and other joints watertight unless otherwise indicated.
- G. Metal Protection:
  - 1. Where aluminum is in contact with dissimilar metals, protect against galvanic action by painting contact surfaces with materials recommended by manufacturer for this purpose or by installing nonconductive spacers.
  - 2. Where aluminum is in contact with concrete or masonry, protect against corrosion by painting contact surfaces with bituminous paint.
- H. Set continuous sill members and flashing in full sealant bed, as specified in Section 079200 "Joint Sealants," to produce weathertight installation.
- I. Install joint filler behind sealant as recommended by sealant manufacturer.
- J. Install components plumb and true in alignment with established lines and grades.
- K. Install operable units level and plumb, securely anchored, and without distortion. Adjust weather-stripping contact and hardware movement to produce proper operation.
- L. Install entrance doors to produce smooth operation and tight fit at contact points.
  - 1. Exterior Doors: Install to produce weathertight enclosure and tight fit at weather stripping.
  - 2. Field-Installed Entrance Door Hardware: Install surface-mounted entrance door hardware in accordance with entrance door hardware manufacturers' written instructions using concealed fasteners to greatest extent possible.
- M. Install glazing as specified in Section 088000 "Glazing."

### 3.3 INSTALLATION OF SUN SHADE SYSTEMS

- A. Comply with manufacturer's product data and installation requirements, including technical bulletins. Protect adjacent work areas and finish surfaces from damage during product installation. Upon request, provide manufacturer's field service consisting of site visit for inspection of product installation.

### 3.4 ERECTION TOLERANCES

- A. Install aluminum-framed entrance and storefront systems to comply with the following maximum tolerances:
  - 1. Plumb: **1/8 inch in 10 feet (3.2 mm in 3 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).**
  - 2. Level: **1/8 inch in 20 feet (3.2 mm in 6 m); 1/4 inch in 40 feet (6.35 mm in 12.2 m).**
  - 3. Alignment:
    - a. Where surfaces abut in line or are separated by reveal or protruding element up to **1/2 inch (12.7 mm)** wide, limit offset from true alignment to **1/16 inch (1.6 mm).**
    - b. Where surfaces are separated by reveal or protruding element from **1/2 to 1 inch (12.7 to 25.4 mm)** wide, limit offset from true alignment to **1/8 inch (3.2 mm).**
    - c. Where surfaces are separated by reveal or protruding element of **1 inch (25.4 mm)** wide or more, limit offset from true alignment to **1/4 inch (6 mm).**
  - 4. Location: Limit variation from plane to **1/8 inch in 12 feet (3.2 mm in 3.6 m); 1/2 inch (12.7 mm)** over total length.

### 3.5 FIELD QUALITY CONTROL

- ~~A. Testing Agency: Engage a qualified testing agency to perform tests.~~
- B. Tests: Perform the following tests on representative areas of aluminum-framed entrance and storefront systems.
  - 1. Water-Spray Test (**field**): Before installation of interior finishes has begun, areas designated by Architect to be tested in accordance with AAMA 501.2 and to not evidence water penetration.
    - a. Perform a minimum of two tests in areas as directed by Architect.
  - 2. Air Leakage (**manufacturer laboratory test**): ASTM E783 at 1.5 times the rate specified for laboratory testing in "Performance Requirements" Article but not more than **0.09 cfm/sq. ft. (0.45 L/s per sq. m)** at a static-air-pressure differential of **1.57 lbf/sq. ft. (75 Pa).**
    - a. Perform a minimum of two tests in areas as directed by Architect.
- C. Aluminum-framed entrance and storefront systems will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.6 MAINTENANCE SERVICE

A. Entrance Door Hardware Maintenance:

1. Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Owner's continued adjustment, maintenance, and removal and replacement of entrance door hardware.

3.7 ENTRANCE DOOR HARDWARE SETS

A. Refer to Section 087100 "Door Hardware" and Section 087111 "Door Hardware Sets."

END OF SECTION 084113

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## SECTION 122413 - ROLLER WINDOW SHADES

### PART 1 - GENERAL

#### 1.1 RELATED DOCUMENTS

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

#### 1.2 SUMMARY

- A. Section Includes:

- 1. Manually-operated roller shades with single rollers.

- B. Related Requirements:

- 1. Division 06 Section "Rough Carpentry" for wood blocking and grounds for mounting roller shades and accessories.

#### 1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product.

- 1. Include styles, material descriptions, construction details, dimensions of individual components and profiles, features, finishes, and operating instructions for roller shades.

- B. Shop Drawings: Show fabrication and installation details for roller shades, including shadeband materials, their orientation to rollers, and their seam and batten locations. Show location and extent of roller shades. Include elevations, sections, details, and dimensions not shown in Product Data. Show installations details, mountings, attachments to other work, operational clearances, and relationship to adjoining work.

- C. Samples for Initial Selection: For each type and color of shadeband material.

- 1. Include Samples of accessories involving color selection.

- D. Samples for Verification: For each type of roller shade.

- 1. Shadeband Material: Not less than 10 inches (250 mm) square. Mark inside face of material if applicable.
  - 2. Installation Accessories: Full-size unit, not less than 10 inches (250 mm) long.

#### 1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

- B. Product Certificates: For each type of shadeband material, signed by product manufacturer.

- C. Product Test Reports: For each type of shadeband material, for tests performed by manufacturer and witnessed by a qualified testing agency.

#### 1.5 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For roller shades to include in maintenance manuals. **Include the following:**
  - 1. Methods for maintaining roller shades and finishes.
  - 2. Precautions about cleaning materials and methods that could be detrimental to fabrics, finishes, and performance.
  - 3. Operating hardware.

#### 1.6 QUALITY ASSURANCE

- A. Installer Qualifications: Experienced installer trained and certified by the manufacturer, for type of installation indicated.

#### 1.7 DELIVERY, STORAGE, AND HANDLING

- A. Deliver roller shades in factory packages, marked with manufacturer, product name, and location of installation using same designations indicated on Drawings.

#### 1.8 FIELD CONDITIONS

- A. Environmental Limitations: Do not install roller shades until construction and finish work in spaces, including painting, is complete and dry and ambient temperature and humidity conditions are maintained at the levels indicated for Project when occupied for its intended use.
- B. Field Measurements: Where roller shades are indicated to fit to other construction, verify dimensions of other construction by field measurements before fabrication and indicate measurements on Shop Drawings. Allow clearances for operating hardware of operable glazed units through entire operating range. Notify Architect of installation conditions that vary from Drawings. Coordinate fabrication schedule with construction progress to avoid delaying the Work.

### PART 2 - PRODUCTS

#### 2.1 MANUFACTURERS

- A. Source Limitations: Obtain roller shades from single source from single manufacturer.

#### 2.2 MANUALLY-OPERATED SHADES WITH SINGLE ROLLERS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
  - 1. Draper Inc.
  - 2. Hunter Douglas Contract.
  - 3. Levolor.
  - 4. MechoShade Systems, Inc.

- B. Chain-and-Clutch Operating Mechanisms: With continuous-loop bead chain and clutch that stops shade movement when bead chain is released; permanently adjusted and lubricated.
  - 1. Bead Chains: Stainless steel.
    - a. Loop Length: Length required to make operations convenient from floor level.
    - b. Limit Stops: Provide upper and lower ball stops.
    - c. Chain-Retainer Type: Clip, jamb mount.
  - 2. Spring Lift-Assist Mechanisms: Manufacturer's standard for balancing roller-shade weight and lifting heavy roller shades.
    - a. Provide for shadebands that weigh more than **10 lb (4.5 kg)** or for shades as recommended by manufacturer, whichever criteria are more stringent.
- C. Rollers: Corrosion-resistant steel or extruded-aluminum tubes of diameters and wall thicknesses required to accommodate operating mechanisms and weights and widths of shadebands indicated without deflection. Provide with permanently lubricated drive-end assemblies and idle-end assemblies designed to facilitate removal of shadebands for service.
  - 1. Roller Drive-End Location: Right side of interior face of shade.
  - 2. Direction of Shadeband Roll: Regular, from back of roller.
  - 3. Shadeband-to-Roller Attachment: Manufacturer's standard method.
- D. Mounting Hardware: Brackets or endcaps, corrosion resistant and compatible with roller assembly, operating mechanism, installation accessories, and mounting location and conditions indicated.
- E. Shadebands:
  - 1. Shadeband Material: Light-filtering fabric.
  - 2. Shadeband Bottom (Hem) Bar: Steel or extruded aluminum.
    - a. Enclosed in sealed pocket of shadeband material.
- F. Installation Accessories:
  - 1. Exposed Headbox: Rectangular, extruded-aluminum enclosure including front fascia, top and back covers, endcaps, and removable bottom closure.
    - a. Height: Manufacturer's standard height required to enclose roller and shadeband assembly when shade is fully open.
  - 2. Endcap Covers: To cover exposed endcaps.
  - 3. Installation Accessories Color and Finish: As selected from manufacturer's full range.

## 2.3 SHADEBAND MATERIALS

- A. Shadeband Material Flame-Resistance Rating: Comply with NFPA 701. Testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
- B. Light-Filtering Fabric: Woven fabric, stain and fade resistant.
  - 1. Source: Roller-shade manufacturer.
  - 2. Type: PVC-coated polyester.

3. Weave: Mesh.
4. Thickness: .026 - .030 in (66-75 mm).
5. Weight: 13.86 - 16.07 oz./sq. yd. (470 - 545g/sq. m).
6. Roll Width: 48 inches (1229 mm).
7. Openness Factor: 5 percent.
8. Color: As selected by Architect from manufacturer's full range.

## 2.4 ROLLER-SHADE FABRICATION

- A. Product Safety Standard: Fabricate roller shades to comply with WCMA A 100.1, including requirements for flexible, chain-loop devices; lead content of components; and warning labels.
- B. Unit Sizes: Fabricate units in sizes to fill window and other openings as follows, measured at 74 deg F (23 deg C):
  1. Outside of Window Jamb Installation (Inside of GWB Jamb): Width and length as indicated by wall opening, with terminations between shades of end-to-end installations at centerlines of mullion or other defined vertical separations between openings.
- C. Shadeband Fabrication: Fabricate shadebands without battens or seams to extent possible except as follows:
  1. Vertical Shades: Where width-to-length ratio of shadeband is equal to or greater than 1:4, provide battens and seams at uniform spacings along shadeband length to ensure shadeband tracking and alignment through its full range of movement without distortion of the material.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances, operational clearances, and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 ROLLER-SHADE INSTALLATION

- A. Install roller shades level, plumb, and aligned with adjacent units according to manufacturer's written instructions.
  1. Opaque Shadebands: Located so shadeband is not closer than 2 inches (51 mm) to interior face of glass. Allow clearances for window operation hardware.
- B. Roller Shade Locations:
  1. Install manually-operated roller shades at all exterior aluminum storefront windows in Media Center C129.

### 3.3 ADJUSTING

- A. Adjust and balance roller shades to operate smoothly, easily, safely, and free from binding or malfunction throughout entire operational range.



3.4 CLEANING AND PROTECTION

- A. Clean roller-shade surfaces after installation, according to manufacturer's written instructions.
- B. Provide final protection and maintain conditions, in a manner acceptable to manufacturer and Installer, that ensure that roller shades are without damage or deterioration at time of Substantial Completion.
- C. Replace damaged roller shades that cannot be repaired, in a manner approved by Architect, before time of Substantial Completion.

END OF SECTION 122413



## SECTION 220800 – PLUMBING COMMISSIONING REQUIREMENTS

### PART 1 - GENERAL

#### 1.1 DESCRIPTION

- A. Commissioning: Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:
  - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
  - 2. Verify and document proper functional performance of equipment and systems.
  - 3. Verify that O&M documentation is complete.
  - 4. Verify that the Owner's operating personnel are adequately trained.

#### 1.2 RELATED WORK

- A. Section 011000 – Summary of Work.
- B. Section 013300 – Submittal Procedures.
- C. Section 017700 – Closeout Procedures.
- D. Section 017900 – Demonstration and Training.
- E. Section 019113 – General Commissioning Requirements.
- F. Division 22 – Plumbing.

#### 1.3 ABBREVIATIONS AND DEFINITIONS

- A. A/E: Architect, Architect/Engineer, and/or Engineer.
- B. ASI: Architectural Supplemental Instruction.
- C. BAS: Building Automation System.
- D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR.
- E. CxA: Commissioning Authority.
- F. Controls Contractor.
- G. CM: Construction Manager.

- H. Cx: Commissioning.
- I. Cx Plan: Commissioning Plan.
- J. Cx RFI: Commissioning Request for Information.
- K. DDC: Direct Digital Control System.
- L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.
- M. EC: Electrical Contractor.
- N. FBO: Furnished By Others.
- O. FT: Functional Performance Test.
- P. IAW: In Accordance With.
- Q. MC: Mechanical Contractor.
- R. O&M: Operation and Maintenance.
- S. OPM: Owner Project Manager.
- T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.
- U. PC: Prefunctional Checklist.
- V. RFI: Request for Information.
- W. Sub(s): Subcontractors or Prime Contractor.
- X. TC: Testing Contractor.
- Y. TBD: To Be Determined.

#### 1.4 PLUMBING SYSTEMS TO BE COMMISSIONED

- A. Domestic hot water systems.
- B. Natural gas supply equipment.
- C. Sump pumps and sump pump controls.

#### 1.5 SUBMITTALS

- A. Refer also to Specification Section 019113, Subsection 1.6.
- B. Provide the CxA a copy of the following items, for the systems to be commissioned:
  - 1. Equipment and System Submittals to include, at minimum, the following:
    - a. Cut Sheets.

- b. Performance data.
- 2 Manufacturer's pre-startup checklists.
  - c. Manufacturer's start-up checklists.
  - d. Installation Instructions.
- 2. Shop drawings (including any resubmittals required by the A/E).
- 3. Test plan.
- 4. Completed field test report, including all completed forms and checklist; and list of all outstanding deficiencies and uncompleted items.
- 5. Operational and maintenance documentation.
- 6. Training plan and training materials.
- 7. As-built documentation.

## **PART 2 - PRODUCTS**

### **2.1 TEST EQUIPMENT**

- A. Refer to Specification Section 019113, Subsection 2.1.
- B. Instrumentation required to verify readings and test system and equipment performance shall be provided by Contractor and made available to Commissioning Authority. Camera equipment capable of viewing an entire pipe assembly at one time.

### **2.2 Cx WEB-BASED COMMISSIONING TOOL**

- A. Refer to Specification Section 019113, Subsection 2.1.

## **PART 3 - EXECUTION**

### **3.1 MEETINGS**

- A. Refer to Specification Section 019113, Subsection 3.3.

### **3.2 START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT**

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.

- B. General

Contractor shall complete plumbing testing as required in sections 221116, 221316, and 223300, and 223400.

- C. Testing Plan

- 1. The subcontractor responsible for providing and installing the equipment completes the testing plan. The test plan will include checklists and procedures with specific boxes or lines for

recording and documenting the tests, and a summary statement with a signature block at the end of the plan.

2. The contractor submits the full test plan to the A/E and CxA for review and approval.

D. Execution of Testing Plan

1. Two weeks prior to testing, the Subs and vendors schedule testing with the OPM, CM and CxA. The performance of the tests are directed and executed by the Sub or vendor.
2. The CxA and possibly the A/E will observe the testing procedures for selected pieces of equipment.
3. The Subs and vendors shall execute testing and provide the CM with a signed and dated copy of the completed testing report. The CM reviews for completion and accuracy, then submits to the CxA and A/E.
4. Only individuals that have direct knowledge and witnessed that a line item task on the testing was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Sub(s) shall clearly list any outstanding items of the initial testing that were not completed successfully. The testing forms and any outstanding deficiencies shall be provided to the CxA within two days of test completion.
2. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the tests in a timely manner, and shall notify the CxA as soon as outstanding items have been corrected.
3. Items left incomplete, which later cause deficiencies or delays during functional performance testing may result in backcharges to the responsible party. Refer to Section 019113, 3.7 – Documentation, Non-Conformance and Approval of Tests.

### 3.3 FUNCTIONAL PERFORMANCE TESTING, VERIFICATION AND VALIDATION

A. Objectives and Scope

1. The contractor will perform functional performance testing of the water heating equipment and any plumbing automation system integration with the EMS.
2. The objective is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.
3. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment and warranty protection.
4. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

5. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before demonstration testing commences.

B. Coordination and Scheduling

1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the testing of all equipment and systems. The CxA will schedule demonstration and validation after written notification from the CM and affected Subs. The CxA shall direct, witness and document the demonstration retesting of equipment and systems. The Subs shall execute the tests.
2. In general, functional performance testing shall not be scheduled until all equipment submittals are approved, testing plans are approved, testing has been satisfactorily completed, and testing report has been provided. Scheduling of testing shall be done with a minimum of two weeks notice prior to testing. Testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

C. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4 DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Refer to Specification Section 019113, Subsection 3.7.

3.5 OPERATION AND MAINTENANCE MANUALS

- A. In addition to installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 019113, subsection 3.8 for further detail.

3.6 TRAINING OF OWNER PERSONNEL

- A. See Specification Section 019113, Subsection 3.9.
- B. Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of cabling systems.
- C. Training shall start with classroom sessions, if necessary, followed by hands-on training on each piece of equipment.

3.7 DEFERRED TESTING

- A. See Specification Section 019113, Subsection 3.10.

END OF SECTION 220800





## SECTION 230800 – HVAC COMMISSIONING REQUIREMENTS

### PART 1 - GENERAL

#### 1.1. DESCRIPTION

- A. Commissioning: Commissioning is a systematic process of ensuring that all building systems perform interactively according to the owner's project requirements and operational needs. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing adjusting and balancing, performance testing and training. Commissioning during the construction phase is intended to achieve the following specific objectives:
  - 1. Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
  - 2. Verify and document proper functional performance of equipment and systems.
  - 3. Verify that O&M documentation left on site is complete.
  - 4. Verify that the Owner's operating personnel are adequately trained.

#### 1.2. RELATED WORK

- A. Section 011000 – Summary of Work
- B. Section 013300 – Submittal Procedures
- C. Section 017700 – Closeout Procedures
- D. Section 017900 – Demonstration and Training
- E. Section 019113 – General Commissioning Requirements

#### 1.3. ABBREVIATIONS AND DEFINITIONS

- A. A/E: Architect, Architect/Engineer, Engineer and/or Design-Builder
- B. ASI: Architectural Supplemental Instruction
- C. BAS: Building Automation System
- D. BoD: Basis of Design. A narrative of how the designer plans to achieve the OPR.
- E. CxA: Commissioning Authority
- F. CC: Controls Contractor
- G. CM: Construction Manager
- H. Cx: Commissioning

- I. Cx Plan: Commissioning Plan
- J. Cx RFI: Commissioning Request for Information
- K. DDC: Direct Digital Control System
- L. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents and cannot be corrected in five (5) minutes time.
- M. EC: Electrical Contractor
- N. FBO: Furnished By Others
- O. FT: Functional Performance Test
- P. IAW: In Accordance With
- Q. MC: Mechanical Contractor
- R. O&M: Operation and Maintenance
- S. OPM: Owner Project Manager
- T. OPR: Owner Project Requirement. A dynamic document expressing how the owner expects the building systems to perform upon project completion.
- U. PC: Pre-functional Checklist
- V. RFI: Request for Information
- W. Sub(s): Subcontractors or Prime Contractor
- X. TAB: Test, Adjust and Balance
- Y. TBD: To Be Determined

#### 1.4. MECHANICAL EQUIPMENT AND SYSTEMS TO BE COMMISSIONED

- A. Mechanical Systems
  - 1. Building automation systems
  - 2. Science room control systems and pressurization
  - 3. Chilled water system, chilled water pumps, piping, and associated equipment.
  - 4. Dehumidification systems
  - 5. Heating hot water system, associated pumps, piping, and equipment
  - 6. Preheat and Reheat water systems and associated pumps and piping
  - 7. Air Handling Units including heat recovery modules
  - 8. Exhaust and other specialty fans
  - 9. Kitchen exhaust systems
  - 10. Variable Air Volume Air terminal units

11. Ductwork
  12. DX systems
  13. Test, Adjust, and Balance of HVAC air and water systems
- B. Building Automation Systems (BAS)
1. The entire BAS shall be subject to commissioning, including all hardware components, software, networking, programming and engineering services, and controls documentation.
  2. Any systems connected to the BAS (monitoring or otherwise) are subject to be commissioned.

#### 1.5. SUBMITTALS

- A. Refer also to Specification Section 019113, Subsection 1.6.
- B. Provide the CxA a copy of the following items, for the systems to be commissioned:
1. Equipment and System Submittals to include, at minimum, the following:
    - a. Equipment Data Sheets
    - b. Performance data
    - c. Manufacturer's pre-startup checklists
    - d. Manufacturer's start-up checklists
    - e. Installation Instructions
  2. Test, Adjust, and Balance (TAB) Reports
    - a. Planning Report - TAB contractor shall submit one copy of planning report (execution plan) to the CxA for review prior to beginning TAB work. At a minimum this report should include:
      - 1) Certifications on all instruments to be used throughout the testing. Certification must be documented within the previous 6 months.
      - 2) Résumés and Certification of individuals who will be balancing the systems.
      - 3) Detailed step-by-step plans for each procedure to be performed by the TAB Contractor.
      - 4) Sample forms to be used for each measurement.
    - b. Initial Test Report – Prior to starting final Balance Phase, submit a copy of the initial test report (TAB punchlist) to the CxA to indicate problem areas to be resolved before final balance is completed.
    - c. Final Report – Submit one copy of final test report to the CxA within 7 days after fieldwork is complete.
  3. Shop drawings (including any resubmittals required by the A/E)
  4. Ductwork - Supply one copy of the duct leakage test results for each test section
  5. Piping - Supply one copy of all of hydrostatic pressure test results
  6. Initial Pre-startup and start-up plan

7. Startup Testing Report
  - a. Prepare startup testing report on a per system basis, documenting the results of executed testing plan.
  - b. Copies of all completed test forms and checklists shall be provided
  - c. List of all outstanding deficiencies and uncompleted items
8. Operational and maintenance documentation
9. Training plan and training materials
10. As-built documentation

## PART 2 - PRODUCTS

### 2.1. TEST EQUIPMENT

- A. Refer to Specification Section 019113, subsection 2.1.

### 2.2. Cx WEB-BASED COMMISSIONING TOOL

- A. Refer to Specification Section 019113, subsection 2.1.

## PART 3 - EXECUTION

### 3.1. MEETINGS

- A. Refer to Specification Section 019113, subsection 3.3.

### 3.2. START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment to be commissioned, according to Section 1.4 above.
- B. General
  1. Pre-functional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full pre-functional checkout. No sampling strategies are used. The pre-functional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.
- C. Start-up and Initial Checkout Plan
  1. The CxA will provide pre-functional checklists (PFCs). PFCs indicate the required procedures to be executed as part of startup and initial checkout of the systems.
  2. The subcontractor responsible for providing and installing the equipment develops the full start-up plan by combining (or adding to) the CxA's pre-functional checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field

checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

3. The full start-up plan shall consist of:
  - a. The CxA's pre-functional checklists.
  - b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end
  - c. The manufacturer's normally used field checkout sheets
  - d. Specifically, the mechanical start-up plan shall also include the contractors TAB plan.
4. The contractor submits the full startup plan to the CxA for review and approval.
5. The CxA reviews and approves the procedures and the format for documenting them, noting any plans that need to be added.

D. Execution of Pre-functional Checklists and Startup

1. Two weeks prior to startup, the Subs and vendors schedule startup and checkout with the OPM, CM and CxA. The performance of the pre-functional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off pre-functional checklists, signatures may be required of other Subs for verification of completion of their work.
2. The CxA and possibly the A/E will observe the procedures for selected pieces of primary equipment.
3. The CxA will observe the physical start-up of all major systems.
4. The CxA will witness piping cleanout procedures and verify any required water or lab tests.
5. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA will observe a sampling of the pre-functional and start-up procedures.
6. The Subs and vendors shall execute startup and provide the CM with a signed and dated copy of the completed start-up and pre-functional tests and checklists. The CM reviews for completion and accuracy, then submits to the CxA.
7. Only individuals that have direct knowledge and witnessed that a line item task on the pre-functional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.
8. Completed startup test report must be provided to CxA prior to functional testing.

E. Deficiencies, Non-Conformance and Approval in Checklists and Startup

1. The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully. The procedures form and any outstanding deficiencies shall be provided to the CxA within two days of test completion.
2. The CxA will work with the Subs and vendors to determine what is required to correct outstanding deficiencies and retest deficiencies of uncompleted items. The CxA will involve the PM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner and shall notify the CxA as soon as outstanding items have been corrected.

3. Items left incomplete, which later cause deficiencies or delays during functional testing may result in back charges to the responsible party. Refer to Section 019113, 3.3 – Documentation, Non-Conformance and Approval of Tests.

### 3.3. FUNCTIONAL PERFORMANCE TESTING

- A. This sub-section applies to functional testing and demonstration for equipment and system in this division.
- B. The general list of equipment and systems to be commissioned is found in section 1.4.
- C. Objectives and Scope
  1. The objective of functional performance testing is to demonstrate that each system is operating according to the owner's project requirements, documented project program, and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.
  2. In general, each system shall be operated through all modes of operation where there is a specified system response.
  3. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting, individual systems has been achieved, the interface or coordinated responses between systems is checked.
  4. The contractor shall supply all personnel and equipment for the demonstration, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. Contractor supplied personnel must be competent with and knowledgeable of all project-specific systems, and automation hardware and software. All training documentation, submittals, installation manuals, and O&Ms, shall be at the job site before functional testing commences.
- D. Development of Test Procedures
  1. The CxA develops specific functional test procedures and forms to verify and document proper operation of each piece of equipment and system. The CxA provides a copy of the test procedures to the A/E, OPM and installing Sub who shall review the tests prior to testing. The A/E and Sub(s) shall point out to the CxA any specific problems as related to feasibility, safety, equipment and warranty protection.
- E. Coordination and Scheduling
  1. The CM shall provide sufficient notice to the CxA regarding the Subs completion schedule for the prefunctional checklists and startup of all equipment and systems. The CxA will schedule functional tests after written notification from the CM and affected Subs. Completed startup testing report must be provided to CxA prior to functional testing. The CxA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.
  2. In general, functional testing shall not be scheduled until all hardware and software submittals are approved, Prefunctional checklists are approved, and start-up has been satisfactorily completed. Further, mechanical system functional testing shall not be scheduled until the final TAB report is approved and all reported deficiencies by TAB firm are corrected. Scheduling of functional testing shall be done with a minimum of two week notice prior to testing. Functional testing of the equipment and systems listed in section 1.4 of this specification section shall not be conducted out of the presence of the CxA and OPM, unless specifically approved to do so in writing by the CxA

or OPM. Any functional testing which occurs outside the presence of the CxA or OPM without written authorization to do so will be required to be re-tested at no expense to the owner.

F. Test Methods

1. Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers.
2. Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
3. Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair dryer rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended overusing the sensor to act as the signal generator via simulated conditions or overwritten values.
5. Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55°F, when the outside air temperature is above 55°F, temporarily change the lockout setpoint to be 2°F above the current outside air temperature.
6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during pre-functional testing.
7. Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

G. Demonstration, Verification and Validation

1. TAB Validation

- a. The air balancing and water balancing is de-bugged, completed and approved before the CxA completes a TAB validation of air-related and water-related equipment or systems. The CxA will direct a TAB checkout by verifying the values reported in the final TAB report. The contractor shall supply all personnel and equipment for the checkout, including, but not limited to, tools, instruments, ladders, lifts, computers, software, cables, etc. The TAB verification shall verify:
  - 1) grilles, diffusers, and registers
  - 2) terminal devices

- 3) all main HVAC systems, including energy recovery systems
- 4) general exhaust fans
- 5) kitchen hood exhaust
- 6) hydronic systems (e.g. HW/CHW) equipment and distribution components

2. Metering System

- a. Demonstrate meters are calibrated in accordance with the manufacturer's published data approved.
- b. Demonstrate accuracy of all meters.
- c. Demonstrate utility monitoring integration with BAS.

H. Problem Solving

1. The CxA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the CM, Subs and A/E.

3.4. DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

- A. Refer to Specification Section 019113, subsection 3.7.

3.5. OPERATION AND MAINTENANCE MANUALS

- A. In addition to Installation manuals, the contractor shall provide one copy of the Operation and Maintenance Manuals to the CxA for the systems to be commissioned. The O&M Manuals shall be provided to the CxA at least 8 weeks prior to the start of Functional Testing. O&M Manuals shall be in electronic form, the file format shall be Adobe Acrobat readable document. The document shall be formatted to include level 1 bookmarks that link to each main section of equipment. Refer to specification section 01 91 13, for further detail.
- B. Refer to specification section 019113, subsection 3.8 for further details.

3.6. TRAINING OF OWNER PERSONNEL

- A. See Specification Section 019113, subsection 3.9.
- B. CxA shall document the completion of comprehensive Owner training. Training shall include the understanding of the systems and the operation and maintenance of each major piece of HVAC equipment or system.
- C. Training shall include classroom sessions, if necessary, followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including AHUs, pumps, VAV terminals, VFDs, etc.

3.7. DEFERRED TESTING

- A. See Specification Section 019113, subsection 3.10.



PART 4 - ATTACHMENT 'A'

SAMPLE AHU PREFUNCTIONAL CHECKLIST

Pre-functional Checklist – Air Handling Units

School \_\_\_\_\_

AIR HANDLER UNIT, AHU#\_\_\_\_\_

Installation Checks

AHUs – Check the following	Initial if Okay	Enter note if deficient
Cabinet and General Installation		
Permanent labels affixed, including for fans		
Casing condition good: no dents, leaks, door gaskets installed		
Access doors close tightly - no leaks		
Boot between duct and unit tight and in good condition		
Vibration isolation equipment installed & released from shipping locks		
Maintenance access acceptable for unit and components		
Sound attenuation installed		
Thermal insulation properly installed and according to specification		
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)		
Clean up of equipment completed per contract documents		
Filters installed and replacement type and efficiency permanently affixed to housing--construction filters removed		
Valves, Piping and Coils		
Pipe fittings complete and pipes properly supported		
Pipes properly labeled		
Pipes properly insulated		
Strainers in place and clean		
Piping system properly flushed		
No leaking apparent around fittings		
All coils are clean and fins are in good condition		
All condensate drain pans clean and slope to drain, per spec		
Valves properly labeled		
Valves installed in proper direction		
OSAT, MAT, SAT, RAT, chilled water supply sensors properly located and secure (related OSAT sensor shielded)		
P/T plugs and isolation valves installed per drawings		
Fans and Dampers		

AHUs – Check the following		
	Initial if Okay	Enter note if deficient
Supply fan and motor alignment correct		
Supply fan belt tension & condition good		
Belts re-tensioned after 80 hours of run time		
Supply fan protective shrouds for belts in place and secure		
Supply fan area clean		
Supply fan and motor properly lubricated		
Return/exhaust fan and motor aligned		
Return/exhaust fan belt tension & condition good		
Return/exhaust fan protective shrouds for belts in place and secure		
Return/exhaust fan area clean		
Return/exhaust fan and motor lube lines installed and lubed		
Filters clean and tight fitting		
Smoke and fire dampers installed properly per contract docs (proper location, access doors, appropriate ratings verified)		
All dampers close tightly		
All damper linkages have minimum play		
Low limit freeze stat sensor located to deal with stratification & bypass		
Ducts (preliminary check)		
Sound attenuators installed		
Duct joint sealant properly installed		
No apparent severe duct restrictions		
Turning vanes in square elbows as per drawings		
OSA intakes located away from pollutant sources & exhaust outlets		
Pressure leakage tests completed		
Branch duct control dampers operable		
Ducts cleaned as per specifications		
Balancing dampers installed as per drawings and Tab's site visit		
Electrical and Controls		
Pilot lights are functioning		
Power disconnects in place and labeled		
All electric connections tight		
Proper grounding installed for components and unit		
Safeties in place and operable		
Starter overload breakers installed and correct size		
VFD		
VFD powered (wired to controlled equipment)		
VFD interlocked to control system		
Static pressure or other controlling sensor properly located and per drawings and calibrated		
Static pressure or other controlling sensor calibrated		

AHUs – Check the following		
	Initial if Okay	Enter note if deficient
Drive location not subject to excessive temperatures		
Drive location not subject to excessive moisture or dirt		
Drive size matches motor size		
Internal setting designating the model is correct		
Input of motor FLA represents 100% to 105% of motor FLA rating		
Appropriate Volts vs. Hz curve is being used		
TAB		
Installation of system and balancing devices allowed balancing to be completed following specified NEBB or AABC procedures and contract documents		
Final		
Smoke and fire dampers and unpowered TU's are open		
Startup report completed with this checklist attached		
Safeties installed and safe operating ranges for this equipment provided to the commissioning agent		
If unit is started and will be running during construction: have quality filters on RA grills, etc. to minimize dirt in the ductwork and coils and in any finished areas. Verify moisture migration is not a problem, due to improper pressures between spaces.		

#### Operational Checks

AHUs – Check the following		
	Initial if Okay	Enter note if deficient
Supply fan rotation correct		
Return/exhaust fan rotation correct		
Return /exhaust fan acceptable noise & vibration		
Supply fan has no unusual noise or vibration		
Inlet vanes aligned in housing, actuator spanned, modulate smoothly and proportional to input signal and EMS readout		
All dampers (OSA, RA, EA, etc.) stroke fully without binding and spans calibrated (follow procedure similar to valves Section 7 below). List each actuated damper here when spanned:		

AHUs – Check the following		
Valves stroke fully and easily and spanning is calibrated (see Section 7 below). List each actuated valve here when spanned:		
	Initial if Okay	Enter note if deficient
Valves verified to not be leaking through coils when closed at normal operating pressure (see Section 7 below)		
The HOA switch properly activates and deactivates the unit		

AHU Checklist Notes:

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

END OF SECTION 230800

## SECTION 233113 – METAL DUCTS

### PART 1 - GENERAL

#### 1.1. SUMMARY

- A. Section includes single and double-wall round, oval and rectangular metal duct and fittings and associated sealants, gaskets, hangers and supports.

#### 1.2. PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE-62.1.

#### 1.3. SUBMITTALS

- A. Product Submittals: For each type of product indicated.
  - 1. Shop Drawings: For all new ductwork and accessories.
    - a. Factory and shop-fabricated ducts and fittings.
    - b. Reinforcement and spacing.
    - c. Seam and joint construction.
    - d. Details for penetrations through fire-rated and other partitions.
    - e. Hangers and supports, including methods for duct and building attachment and vibration isolation.
    - f. Sheet metal thicknesses.
  - 2. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
    - a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
    - b. Suspended ceiling components.
    - c. Structural members to which duct will be attached.
    - d. Size and location of initial access modules for acoustical tile.
    - e. Penetrations of smoke barriers and fire-rated construction.
    - f. Items penetrating finished ceiling
- B. Construction Submittals:

1. Leakage Test Report: Documentation of work performed for compliance with ASHRAE 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
- C. Close-Out Submittals:
  1. As-Built Documents: Provide revised coordination drawings to match the installed conditions.

#### 1.4. DEFINITIONS

- A. System Operating Pressure: Duct system operating pressure is equal to the scheduled external static pressure, unless otherwise noted.
  1. Duct downstream of air terminal units, between terminal unit discharge and diffuser inlet, the operating pressure may be reduced to 1-inch w.g., unless otherwise noted.

### PART 2 - PRODUCTS

#### 2.1. SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations and other imperfections.
- B. Galvanized Steel Sheets: Comply with ASTM A 653/A 653M.
  1. Galvanized Coating Designation:
    - a. G60: Non-hazardous systems such as supply, return, ventilation, relief and general building exhaust duct installed indoors.
    - b. G90: Hazardous exhaust duct and all duct installed outdoors.
  2. Finishes for Surfaces Exposed-to-View: Painted.
- C. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 316 or 304, cold rolled, annealed, sheet. Exposed surface finish shall be No.4.
- D. Aluminum Sheets: Comply with ASTM B209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  1. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36-inches or less; 3/8-inch minimum diameter for lengths longer than 36-inches.

#### 2.2. DUCT CONSTRUCTION

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class with the following exceptions:
  1. Minimum Sheet Metal Thickness:

- a. Non-hazardous ducted systems including supply, return, ventilation, relief and general building exhaust air.
  - 1) Galvanized Sheet Steel: 0.028-inches (24-gage).
  - 2) Stainless Sheet Steel: 0.025-inches (24-gage).
  - 3) Aluminum Sheet Metal: 0.020-inches (24-gage).
2. Minimum Construction Standards: Refer to the Table below for minimum construction standards in addition to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

METAL DUCT MINIMUM CONSTRUCTION STANDARDS

DUCT SYSTEMS	MAXIMUM OPERATING PRESSURE (+/- IN WG)	SMACNA DUCT PRESSURE CLASS. (+/- IN WG)	SMACNA SEAL CLASS (A, B or C)	SMACNA LEAKAGE CLASS (CL)	LONGITUDINAL SEAM TYPES	TRANSVERSE JOINT TYPES	FITTING CONSTRUCTION
RECTANGULAR DUCT	1.0	1	B	8	L-1	T-1, 3, 6, 17, 19, 22, 24, <b>25b</b> (Note #3)	6, 7 and 8
	1.5	2	B	8	L-1	T-1, 3, 6, 17, 19, 22, 24, <b>25b</b> (Note #3)	6 and 7
	2.5	3	A	8	L-1	T-17, 19, 22, and 24 (Note #3)	6 and 7
	3.0	4	A	4	L-1	T-22 (Note #3)	6 and 7
	5.0	6	A	4	L-1	T-22 (Note #3)	6 and 7
	8.0	10	A	4	L-1	T-22 (Note #3)	6 and 7
ROUND DUCT WITH LONGITUDINAL SEAMS	1.0	1	B	8	RL-4, 5, 6A, 6B, 7 and 8	RT-1, 2, 3, 4, 5 and 6 (Note #4)	10 and 14
	1.5	2	B	8	RL-4 and 5	RT-1 and 2 (Note #4)	10, 11, 13 and 14
	2.5	3	A	4	RL-4 and 5	RT-2 (Note #4)	10, 11, 13 and 14
	3.0	4	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
	5.0	6	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
	8.0	10	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #4)	10, 11, 13 and 14
ROUND DUCT WITH SPIRAL SEAMS	1.0	1	B	8	RL-1 (Spiral)	RT-1 and 2 (Note #4)	10, 11, 13 and 14
	1.5	2	B	8	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	2.5	3	A	4	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	3.0	4	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	5.0	6	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
	8.0	10	A	2	RL-1 (Spiral)	RT-2 (Note #4)	10, 11, 13 and 14
FLAT OVAL DUCT WITH LONGITUDINAL SEAMS	1.0	1	B	8	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	1.5	2	B	8	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	2.5	3	A	4	RL-4 and 5	RT-2 (Note #5)	12, 13 and 14
	3.0	4	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
	5.0	6	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
	8.0	10	A	2	RL-4 and 5 (Poss. Press. Only)	RT-2 (Note #5)	12, 13 and 14
FLAT OVAL DUCT WITH SPIRAL SEAMS	1.0	1	B	8	RL-1 (Spiral)	RT-1 and 2 (Note #5)	12, 13 and 14
	1.5	2	B	8	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	2.5	3	A	4	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	3.0	4	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	5.0	6	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14
	8.0	10	A	2	RL-1 (Spiral)	RT-2 (Note #5)	12, 13 and 14

NOTES:

1. REFER TO SMACNA 'HVAC DUCT CONSTRUCTION STANDARD - METAL AND FLEXIBLE' (2005) FOR SEAM, JOINT AND FITTING TYPES.
2. REFER TO SMACNA 'HVAC AIR DUCT LEAKAGE TEST MANUAL' (2012) FOR PRESSURE, SEAL AND LEAKAGE CLASSES.
3. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE TYPE 35 OR 25, OR EQUAL BY WARD OR NEXUS.
4. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE SPIRAL-MATE, OR EQUAL BY WARD OR NEXUS.
5. FACTORY-FABRICATED SLIDE-ON CONNECTORS ALSO MAY BE USED, DUCTMATE OVAL-MATE, OR EQUAL BY WARD OR NEXUS.
6. OPERATING PRESSURES ARE BASED ON MAXIMUM DESIGN PRESSURES, ALSO REPRESENTED AS EXTERNAL STATIC PRESSURES (ESP).
7. USE MINIMUM SMACNA DUCT PRESSURE CLASSIFICATION OF 1 IN WG. DO NOT USE 1/2 INCH CLASSIFICATION.

B. Double-Wall Duct:

1. Double-wall rectangular ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.

- a. Interstitial Insulation: Comply with Section 230713.
  - b. Minimum Thermal Resistance: Comply with Section 230713.
  - c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
  - d. Inner Duct: Minimum 24-gage solid galvanized sheet steel.
2. Double-wall round and flat-oval ducts and fittings shall be fabricated in an off-site dedicated ductwork fabrication shop. Field fabricated double-wall duct will not be accepted.
  - a. Interstitial Insulation: Comply with Section 230713
  - b. Minimum Thermal Resistance: Comply with Section 230713
  - c. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
  - d. Inner Duct: Minimum 24-gage solid galvanized sheet steel.
- C. Intermediate Reinforcement: Match duct material.
- D. Elbow Configuration:
  1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
    - a. Radius Type RE-1 with minimum 1.5 radius-to-diameter ratio.
    - b. Radius Type RE-3 with minimum 1.0 radius-to-diameter ratio and two vanes.
    - c. Mitered Type RE-2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
      - 1) Fabricate elbows with single thickness blades with 2-inch inside radius for ducts with dimensions up to 36x36 and double thickness blades for dimensions 36x36 and larger.
      - 2) Turning vanes may be deleted when duct dimensions are less than 12x12.
  2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
    - a. Elbows shall be solid welded gored type constructed in accordance with Fig. 3-6 and Table 3-1 of SMACNA HVAC Duct Construction Standards. Mitered elbows may only be used where indicated on the Drawings. When used, mitered elbows shall always be supplied with single thickness turning vanes.
    - b. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".
      - 1) Velocity up to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
      - 2) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
    - c. Round Elbows:
      - 1) Diameter 8-inches and Smaller: Stamped or pleated.



- a) Adjustable elbows with lock-form joints are also acceptable.
  - 2) Diameter 10-inches and Larger: Welded gore-type.
    - a) 90-degree elbows shall have minimum 5 gores.
    - b) 45-degree elbows shall have minimum 3 gores.
- E. Branch Configuration:
  - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
    - a. Rectangular Main to Rectangular Branch: 45-degree entry.
    - b. Rectangular Main to Round Branch:
      - 1) Velocity up to 1500 fpm: Conical.
      - 2) Velocity greater than 1500 fpm: 45-degree lateral.
  - 2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
    - a. Round and Flat Oval Main to Round Branch:
      - 1) Velocity up to 1000 fpm: 90-degree tee.
      - 2) Velocity up to 2000 fpm: Conical.
      - 3) Velocity greater than 2000 fpm: 45-degree lateral.
  - 3. Construct tees, bends, and elbows with minimum radius 1-1/2 times centerline duct width. Where not possible and where rectangular elbows are used, provide airfoil turning vanes. Where acoustical lining is indicated, furnish turning vanes of perforated metal with glass fiber insulation.
  - 4. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
  - 5. Fabricate continuously welded round and oval duct fittings two gages heavier than duct gages indicated in SMACNA Standard. Minimum 4-inch cemented slip joint, brazed or electric welded. Prime coat welded joints.
  - 6. Provide standard 45-degree lateral wye takeoffs. When space does not allow 45-degree lateral wye takeoff, use 90-degree conical tee connections. Straight 90-degree round take-offs are allowed off rectangular ducts for single diffuser taps only.
  - 7. Divided or diverging flow fittings shall be constructed as separate fittings. Tap collars welded into spiral duct sections are not acceptable.
- F. Exhaust Hood Connections: Gasketed flanges compatible with hood usage.
- G. General Cleanliness Requirements: Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines".
  - 1. Minimum Duct Cleanliness Level: C ("Advanced Level")
    - a. Internal surfaces shall be wiped clean after fabrication prior to sealing for shipment.
    - b. Self-adhesive labels may be affixed to only the outside surfaces of the duct.

### 2.3. TRAVERSE DUCT CONNECTION SYSTEM

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
  - 1. Ductmate.
  - 2. Ward.
  - 3. Nexus.
- B. Product Description: SMACNA "F" rated or SMACNA "J" rated rigidity class connection, interlocking angle and duct edge connection system with sealant, gasket, cleats, and corner clips.
- C. Duct connectors shall be equal to Ductmate 35 or 25 Systems, slide-on type. The 35 System joint shall be the equivalent of a SMACNA "J" connection. The 25 System joint shall be the equivalent of the SMACNA "F" connection. Duct connectors shall be tested by an independent recognized testing laboratory.
- D. Duct connectors shall consist of roll formed angle frames with integral sealant, corner pieces with nuts and bolts, metal cleats and gasketing. (Metal cleats only, PVC cleats not acceptable, with the exception of breakaway joints at fire damper sleeves.)
- E. Gasketing shall be equal to Ductmate Type 440 synthetic polymer (Butyl) based gasket/sealing tape or approved equal.
- F. Connectors shall be selected for the system duct construction specified. Select in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible and the manufacturers published criteria for positive and negative applications. The manufacturer shall assist in the selection of all duct connectors. Select methods of construction and gages as required to accommodate prefabricated duct connectors.
- G. Angle flange connectors shall be fastened in each corner and 12-inches o/c minimum thereafter unless the MFR requires more stringent fastening. The type/style of fastening must be submitted for approval prior to ductwork fabrication.

### 2.4. PRE-FABRICATED GREASE DUCTS

- A. Description: Zero-clearance double-wall metal vents tested according to UL 1978 and rated for 500 deg F continuously, or 2000 deg F for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.
- B. Construction: ASTM A 666, Type 304 stainless steel inner shell and stainless steel outer jacket with No. 4 finish when exposed-to-view, separated by at least 2-inch annular space filled with high-temperature, ceramic-fiber insulation.
- C. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.

### 2.5. SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
- B. Two-Part Tape Sealing System:

1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
  2. Tape Width: 4 inches.
  3. Sealant: Modified styrene acrylic.
  4. Water resistant.
  5. Mold and mildew resistant.
  6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  7. Service: Indoor and outdoor.
  8. Service Temperature: Minus 40 to plus 200 deg F.
  9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
  10. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
  2. Solids Content: Minimum 65 percent.
  3. Shore A Hardness: Minimum 20.
  4. Water resistant.
  5. Mold and mildew resistant.
  6. VOC: Maximum 75 g/L (less water).
  7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
  8. Service: Indoor or outdoor.
  9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
- D. Flanged Joint Sealant: Comply with ASTM C 920.
1. General: Single-component, acid-curing, silicone, elastomeric.
    - a. Type: S.
    - b. Grade: NS.
    - c. Class: 25.
    - d. Use: O.
  2. For indoor applications, sealant shall have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

## 2.6. HANGERS AND SUPPORTS

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

## PART 3 - EXECUTION

### 3.1. DUCT SCHEDULE

- A. General Building Air Systems: Applies to general building supply, return, exhaust, ventilation and relief air duct. Refer to Part 2, Metal Duct Minimum Construction Standards chart for construction standards for General Building Air Systems ductwork. Refer to this Part 3 Duct Schedule section for special applications.
  - 1. Indoor Duct:
    - a. Concealed or Exposed to View in Mechanical Rooms: Single-wall galvanized sheet steel. Round and oval duct shall have longitudinal or spiral seams.
    - b. Exposed to View in Occupied Spaces: Double-wall galvanized sheet steel. Round and oval duct shall have spiral seams.
  - 2. Special Applications:
    - a. Shower, Bathing, and Dishwashing Areas: Duct up to 10-feet from each air inlet shall be constructed with Type 304 stainless steel or aluminum.
- B. Air Plenums: Applies to air plenums for general building ventilation and relief air systems.
  - 1. Construction: Plenums shall be constructed with materials matching connected duct construction.
  - 2. Access Doors: Refer to Section 233300 for access door requirements.
- C. Kitchen Grease (Type 1 Commercial) Hood Exhaust Air: Install per NFPA 96.

1. Construction: Single-wall Type 304 stainless sheet steel or carbon sheet steel when concealed. Single-wall Type 304 stainless sheet steel with No. 4 finish when exposed-to-view. Duct shall have minimum thickness of 16-gage.
  2. Construction: Factory-fabricated, double-wall stainless steel with No. 4 finish when exposed-to-view.
  3. Operating Pressures up to 3-inches w.g.
    - a. SMACNA Duct Pressure Class: 4-inches w.g.
    - b. SMACNA Seal Class: Welded seams, joints and penetrations.
    - c. SMACNA Leakage Class: Liquid-tight.
- D. Clothes Dryer Exhaust Air:
1. Construction: Single-wall aluminum sheet, minimum 0.020-inch thick and minimum 4-inches diameter, with a smooth interior finish and longitudinal seams.
  2. Operating Pressures up to 1-inch w.g.
    - a. SMACNA Duct Pressure Class: 2-inches w.g.
    - b. SMACNA Seal Class: B
    - c. SMACNA Leakage Class: 8

### 3.2. DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Duct Dimensions: Dimensions in the construction documents indicate as follows:
  1. Rectangular Duct: Nominal inside width and height of the duct.
  2. Round Duct: Nominal inside diameter of the duct.
  3. Oval Duct: Nominal inside width and depth diameter (of the round sides connecting the flat portions) of the duct.
  4. Double-Wall Duct: For double-wall duct, the inside is defined as the inner-duct.
- C. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- D. Install ducts according to SMACNA's "Duct Cleanliness for New Construction Guidelines".
  1. Store duct, fittings and accessories on pallets in a clean and dry location.
  2. All sections of duct, fittings and accessories shall be sealed for shipping and storage. They may be sealed at all openings with polyethylene film, shrink-wrapped, bagged or equivalent. Exposed openings shall remain sealed until temporary filtration is in place.
  3. Temporary filter media shall be installed on both return and exhaust ducts/inlets if system is operated for conditioning prior to occupancy.

4. Internal surfaces shall be wiped clean as each is installed to prevent construction dust and debris from accumulating.
- E. Install round and flat-oval ducts in maximum practical lengths.
- F. Install ducts with fewest possible joints.
- G. Install factory or shop fabricated fittings for changes in direction, size, and shape and for branch connections.
- H. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
- I. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- J. Install ducts with a clearance of 1-inch plus allowance for insulation thickness.
- K. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- L. Where ducts pass through non-fire-rated interior partitions and exterior walls, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- M. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements of the specifications and drawings for fire and smoke dampers.
- N. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."

### 3.3. DUCT WELDING

- A. Duct welding materials and methods shall be in accordance with AWS Standard D9.1-90 Sheet Metal Welding Code.
- B. Electrode material and flux shall be compatible with the sheet metal material being welded.
- C. Re-coat any galvanizing damaged as a result of welding with a zinc-rich paint, such as Porter Zinc-Lock 351 – Gray.
- D. Stainless Steel Ductwork Welding:
  1. Welding Process: Welding process shall be inert gas shielded tungsten arc process. Electric current for welding shall be direct current, straight polarity (electrode negative and work positive).
  2. Shielding and Purging: Shielding and purging gas shall be welding grade helium, argon or a mixture of both.
  3. Electrodes: Electrodes shall be 2-percent thoriated tungsten conforming to AWS classification and complying with AWS A5.4, AWS A5.9, and AWS A5.12.
  4. Grinding and Polishing: The inside and outside of welds shall have burrs and rough spots removed with a tungsten carbide file or grinder. Final polishing shall be with the proper grit (free of iron) abrasive grinder with flexible flap, drum or roll wheel.

### 3.4. INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

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

### 3.5. ADDITIONAL REQUIREMENTS FOR COMMERCIAL KITCHEN HOOD EXHAUST DUCT

- A. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease and sloped a minimum of 2 percent to drain grease back to the hood.
- B. Install residue traps with cleanouts at base of vertical risers. Cleanouts shall be located and arranged to be accessible for regular cleaning.
- C. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of 12 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
- D. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.

### 3.6. ADDITIONAL REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

- A. Install duct in accordance the manufacturer's recommended installation instructions whichever they are more stringent.
- B. Provide a factory-fabricated aluminum dryer vent termination with an integral backdraft damper at the exterior termination. Bird and insect screens are not acceptable.
- C. Support duct from building structure at minimum 4-foot on-center.
- D. Provide a temporary cap on the interior duct opening until the clothes dryer is installed.
- E. Provide protective galvanized steel shield plates, minimum 0.062-inches thick, to prevent penetrations of the duct. Locate shield plates on the finish face of all framing members where there is less than 1.5-inches between the duct and the finish face of the framing member. Shield plates shall extend 2-inches above sole plates and below top plates.
- F. Transition ducts shall not be concealed by the building construction. Transition ducts shall be listed and labeled for their application and be no more than 8-foot long.
- G. Penetrations through life-safety rated assemblies shall meet the requirements of UL 263 or ASTM E 119. Fire and/or smoke-rated dampers are not acceptable.
- H. Provide permanent labels indicated the maximum equivalent length of exhaust duct.

### 3.7. HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.

1. Where practical, install concrete inserts before placing concrete.
  2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
  4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
  5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at maximum intervals of 10 feet.
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

### 3.8. CONNECTIONS

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

### 3.9. PAINTING

- A. Paint interior of all metal duct that is visible through registers and grilles and that does not have duct liner.
- B. Paint exterior of all galvanized metal duct that is exposed-to-view. Do not paint stainless steel duct unless otherwise directed.
1. Exception: Do not paint duct in mechanical rooms, mezzanines or penthouses.
- C. Painting Duct:
1. Clean duct of dirt, grease and lubricants with a non-hydrocarbon "green" cleaner.
  2. Prime duct with 2 coats of water-based white acrylic primer paint designed for use with galvanized steel.
  3. Finish duct with 2 coats of latex paint.
    - a. Exterior Duct Surfaces: Color and finish shall be chosen by the owner/ architect.
    - b. Interior Duct Surfaces: Flat black.
- D. Apply paint and primer at the recommended spreading rate and film thickness as recommended by the paint manufacturer.
- E. Apply paint and primer within the environmental conditions recommended by the paint manufacturer but not less than 55F; not more than 90F; and not more than 70% RH.



- F. Mill phosphatized or bonderized "paint grip" steel is not acceptable. Galvannealed sheet metal using a continuous hot-dipping method is an acceptable alternative.

### 3.10. FIELD QUALITY CONTROL

- A. Engineer to inspect all ductwork at operating pressure prior to insulation for leakage. All leakage shall be repaired.
- B. Perform tests and inspections.
- C. Leakage Pressure Tests:
  - 1. Test 100% of supply, return, exhaust, relief and ventilation duct at pressures equal to their maximum static pressure classifications. Do not over-pressurize systems above their maximum designed operating pressure.
    - a. Low pressure duct (2-inches w.g. or less) listed below shall be tested for leakage.
      - 1) Return air duct for return plenum systems under negative pressure and greater than 30 ft. total length of duct.
      - 2) Return air duct from the intake of blower coil units under negative pressure and greater than 30 ft. total length of duct.
      - 3) Exhaust and Relief air duct under negative or positive pressure as per normal operation and greater than 30 ft total length of duct.
      - 4) Outdoor and Ventilation air duct under negative pressure and greater than 30 ft. total length of duct.
      - 5) Supply air duct from the discharge of terminal units, fan coil units and blower coil units under positive pressure and greater than 30 ft. total length of duct.
  - 2. Test duct leakage per 2013 ASHRAE Fundamentals Handbook Chapter 21 and 2016 ASHRAE HVAC Systems and Equipment Handbook Chapter 19 with an average leakage rate for each duct system as specified in Table 3 for the leakage class specified in Part 3 of this section.
  - 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - 4. Test for leaks before applying external insulation.
  - 5. Provide 10-day notice for testing.
  - 6. Testing performed prior to the installation of duct accessories, such as dampers and access doors, is not valid. Alterations of the systems due to incomplete or non-conforming work made after testing will void previous test results and require new testing at no additional cost to the owner or engineer. Verify related work is complete before starting.
- D. Leakage Light Tests:
  - 1. Test 100% of commercial kitchen hood exhaust air duct. Perform leakage test using light complying with the current edition of the Mechanical Code and the following, whichever is stricter.
    - a. Perform the tests in low ambient light levels.
    - b. Pass a 2500 lumen light source, such as a 150-watt incandescent or 40 watt LED lamp, through the entire length of the duct.

- c. Inspect 100% of all joints to ensure they are liquid-tight.
  - d. If light is detected at any point, remake and retest joints until all pass.
  - e. Once the duct is completely tested and proved compliant, allow the Owner and Engineer to witness the test.
- E. Duct System Cleanliness Tests:
  - 1. Visually inspect duct system to ensure that no visible contaminants are present.
  - 2. Test sections of metal duct system, chosen randomly by Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    - a. Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
- F. Duct system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 233113

## SECTION 260800 – ELECTRICAL COMMISSIONING

### PART 1 - GENERAL

#### 1.1 WORK INCLUDED

- A. Systems and equipment Start-Up, Pre-Functional Checklists and Functional Performance Testing.
- B. Validation of proper and thorough installation of Division 26 systems and equipment.
- C. Generic Start-Up Documentation for electrical systems and equipment.
- D. Development of final Start-Up Documentation for electrical systems and equipment.
- E. System Start-Up and Turn-Over procedures.
- F. Coordination and execution of Training Events.

#### 1.2 GENERAL DESCRIPTION

- A. Commissioning (Cx) is the process of ensuring that (i) all building systems are installed and perform interactively according to the design intent; (ii) that systems are efficient and cost effective and meet the Owner's operational needs; (iii) that the installation is accurately documented; and (iv) that the Operators are adequately trained. Commissioning serves as a tool to minimize post-occupancy operational problems, and establishes testing and communication protocols to advance the building systems from installation to optimized, fully-dynamic operation.
- B. Commissioning Authority (CxA) shall work with the Contractor and the design engineers to direct and oversee the Cx process and perform Pre-Functional Checklists and Functional Performance Testing.
- C. The Commissioning Plan outlines the Cx process beyond the Construction Contract, including design phase activities and design team/owner responsibilities. The specification Sections dictate all requirements of the commissioning process relative to the construction contract. The Cx Plan is not part of the construction contract, although it is available for reference at the request of the Contractor.
- D. This Section outlines the Cx procedures specific to the Division 26 Contractors. Requirements common to all Sections are specified in Sections 019100 and 019110 This Section and other sections of the specification details the Contractor's responsibilities relative to the Cx process.

#### 1.3 SCOPE

- A. The following systems and equipment are included in the Scope of Commissioning for this project:
  - 1. Lighting and Lighting Controls
  - 2. Switchboards  $\geq 600A$  (grounding and bonding)
  - 3. Disconnect Switches
  - 4. Intercom
  - 5. Utility metering connected to BAS

#### 1.4 RELATED WORK AND DOCUMENTS

- A. The Cx process references many related Sections, particularly Section 019100 - General Commissioning. It is important for all Contractors subject to the Cx process to be familiar with Section 019100.

- B. Refer to Section 019100 for a complete list of Sections on Related Work.

#### 1.5 DEFINITIONS AND ABBREVIATIONS

- A. Refer to Section 019100 for a complete list of Definitions and Abbreviations.

#### 1.6 REFERENCE STANDARDS

- A. National Electric Code (NEC)
- B. American Society for Testing and Materials (ASTM)
- C. Electronics Industry Association/Telecommunications Industry Association (EIA/TIA)
- D. Illuminating Engineering Society (IES)
- E. Institute of Electrical and Electronics Engineers (IEEE)
- F. International Electrical Testing Association (NETA)
- G. National Electrical Manufacturers Associates (NEMA)
- H. National Fire Protection Association (NFPA)
- I. Underwriters Laboratory, Inc. (UL)
- J. Refer to Section 019100 for additional Reference Standards.

#### 1.7 DOCUMENTATION

- A. Documentation shall be as required in Section 019100.

#### 1.8 SEQUENCING AND SCHEDULING

- A. Refer to Section 019100.

#### 1.9 COORDINATION MANAGEMENT PROTOCOLS

- A. Coordination responsibilities and management protocols relative to Cx are initially defined in Section 019100 and the Cx Plan, but shall be refined and documented in the Construction Phase Cx Kick-Off Meeting. Contractor shall have input into the protocols to be used and all Parties will commit to scheduling obligations. The CxA will record and distribute.

#### 1.10 CONTRACTOR RESPONSIBILITIES

- A. Refer to Section 019100: Detailed Contractor responsibilities common to all Divisions are specified in Section 019100. The following are additional responsibilities or notable responsibilities specific to Division 26.
- B. Construction Phase
  - 1. Provide skilled technicians qualified to perform the work required.
  - 2. Provide factory-trained and authorized technicians where required by the Contract Documents.

3. Prepare and submit required draft Start-Up Documentation and submit along with the manufacturer's application, installation and start-up information.
4. Provide assistance to the CxA in preparation of the specific Functional Performance Test (FPT) procedures. Contractors, subcontractors and vendors shall review FPT procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests. Damage caused to equipment performed in accordance with the approved procedures will be the responsibility of the Contractor.
5. Thoroughly complete and inspect installation of systems and equipment as detailed throughout Contract Documents, as required by reference or industry standards, and as specifically indicated elsewhere this Section.
6. Start-Up, test/adjust and Turn-Over systems and equipment prior to functional performance testing by the CxA. Approved Start-Up Documentation shall be in accordance with Contract Documents, reference or industry standards, and specifically elsewhere in Part I of this Section.
7. Provide necessary personnel to CxA to demonstrate PFC items and execution of FPT commissioning work (e.g. remove electrical panels, remove air handling unit or fan coil panels, provide access to roof areas or secured mechanical rooms, open access doors, etc.) as required to complete work.
8. Record Start-Up on approved Start-Up Documentation forms and certify that the systems and equipment have been started and or tested in accordance with the requirements specified above and in Section 01 09 00. Each task or item shall be indicated with the Party actually performing the task or procedure.
9. Coordinate the work of the Electrical Testing Agency and the Cx requirements.

C. Acceptance Phase

1. Assist CxA in Functional Performance Testing. Assistance will typically include the following:
  - a. Manipulate systems and equipment to facilitate Functional Performance Testing (as specified in Section 019100, Section 019110, and the Cx Plan; in some cases this will entail only an initial sample);
  - b. Provide any specialized instrumentation necessary for Functional Performance Testing;

1.11 EQUIPMENT SUPPLIER RESPONSIBILITIES

- A. Refer to Section 019100.

1.12 CONTRACTOR NOTIFICATION AND SCHEDULING

- A. Refer to Section 019100.

1.13 START-UP DOCUMENTATION

- A. Refer to Section 019100.

1.14 FUNCTIONAL PERFORMANCE TESTING

- A. For applicable systems and equipment, Contractor shall participate in the initial samples of Functional Performance Testing as stipulated in Section 019100 and Section 019110.

1.15 FPT ACCEPTANCE CRITERIA

- A. Acceptance criteria for tests are indicated in Section 019110 and in the specification Sections applicable to the systems being tested. Unless indicated otherwise, the criteria for acceptance will be that specified with the individual system, equipment, component, or device, which shall typically conform to NFPA 70B and International Electrical Testing Association (NETA) testing specifications NETA ATS-2013.

#### 1.16 TRAINING

- A. Contractors, subcontractor, vendors, and other applicable Parties shall prepare and conduct training sessions on the installed systems and equipment they are responsible for per the requirements of Section 019100 and the individual Specifications.

### PART 2 - PRODUCTS

#### 2.1 INSTRUMENTATION

- A. General: All testing equipment used by any Party shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified. Unless otherwise noted, all equipment shall be calibrated according to the manufacturer's recommended intervals. Calibration tags shall be affixed or certificates readily available.

#### 2.2 COMMISSIONING RESOLUTION TRACKING FORM

- A. The CA will document design and construction issues of scoped commissioned equipment and systems and track them using the Commissioning Resolution Tracking Form (RTF). This RTF will help to ensure that issues discovered during the commissioning process are documented, addressed, followed up, and kept visible to the Commissioning Team until resolved. The RTF will be maintained throughout the duration of the project through all phases.

### PART 3 - EXECUTION

#### 3.1 GENERIC START-UP DOCUMENTATION - GENERAL

- A. Part III of this Section outlines 'generic' or minimally acceptable Start-Up Documentation (which are defined to include both 'Start-Up Checks' and 'Start-Up Tests') and individual systems training requirements for systems and equipment. These procedures are the direct responsibility of the Contractor as a basic element of validating that the installation is correct per normal quality control practices. These items shall provide a minimally acceptable guideline for required Contractor development of Start-Up Documentation. Contractor shall synthesize these minimum requirements along with their own internal quality control practices, those of the manufacturer, and any applicable codes and standards to develop specific and itemized final Start-Up Documentation specific to the equipment and systems installed on this project.
- B. Section 019100 defines the systems and equipment Start-Up process in detail and provides definitions for Start-Up Documentation, including the generic Start-Up Documentation provided below.

#### 3.2 START-UP CHECKS COMMON TO ALL SYSTEMS

- A. The following Start-Up verifications and procedures shall be considered common to all systems:
  - 1. Checkout shall proceed from lower level devices to larger components to the entire system operation.
  - 2. Verify labeling is affixed per specification and visible.
  - 3. Verify prerequisite procedures are done.

4. Inspect for damage and ensure none is present.
5. Verify system is installed per the manufacturer's recommendations.
6. Verify system has undergone Start-Up per the manufacturer's recommendations.
7. Verify that access is provided for inspection, operation and repair.
8. Verify that access is provided for eventual replacement of the equipment.
9. Verify that record drawings, submittal data and O&M documentation accurately reflect the installed systems.
10. Verify all gauges and test ports are provided as required by contract documents and manufacturer's recommendations.
11. Verify all recorded nameplate data is accurate.
12. Verify that the installation ensures safe operation and maintenance.
13. Verify specified replacement material/attic stock has been provided as required by the Contract Documents.
14. Verify all rotating and moving parts are properly lubricated.
15. Verify all monitoring and ensure all alarms are active and set per Owner's requirements.
16. Complete all nameplate data and confirm that ratings conform to the design documents.

### 3.3 SWITCHBOARDS

- A. Include all applicable 'Start-Up Checks Common to All Systems'. Additional Start-Up Checks and Tests are as follows.
- B. General: Provide the services of a Factory-Trained Manufacturer's Representative to assist the Contractor in the installation and start-up service of the equipment for a period of 3 working days in 3 visits and train Owner's maintenance personnel as specified below. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.
- C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.
  1. Visual and Mechanical inspections listed in NETA ATS-2013.
  2. Check calibration/setting of trip devices using system coordination study.
  3. Verify calibration/setting of digital metering.
- D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
  1. Visually and mechanically inspect to include the following: anchoring; grounding; torque of feeder and incoming bus duct connections; feeder cable and integral main bus connections; switchgear section alignments; electrical clearances; mechanical operation of breaker/fuse drawout elements and operating mechanisms, manual trip function; main bus safety shutters; and installation verification using manufacturer's checklist.
  2. Electrical tests listed in NETA ATS-2013. Optional tests are not required.
  3. Test each breaker in accordance with the Circuit Breaker tests listed in this Section.

4. Conduct operational/functional tests of protective relaying. Time-current tests shall be conducted and trip points shall be set per the Short Circuit and Coordination Study.
  5. Test all key-interlocking operations and load transfer sequences.
- E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

### 3.4 DISCONNECT SWITCHES

- A. Include all applicable 'Start-Up Checks Common to All Systems'. Additional Start-Up Checks and Tests are as follows.
- B. General: Refer to the quality control requirements listed in applicable Sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.
- C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.
1. Visual and Mechanical inspections listed in NETA ATS-2013.
  2. Check installation of warning nameplates and equipment nametags.
- D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
1. Electrical tests listed in NETA ATS-2013.
- E. Training: Train Owner's maintenance personnel on procedures and schedules related to troubleshooting, servicing, and preventative maintenance.

### 3.5 LIGHTING CONTROLS

- A. Include all applicable 'Start-Up Checks Common to All Systems'. Additional Start-Up Checks and Tests are as follows.
- B. General: Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.
- C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.
1. Ensure all labeling for all relays/contactors is affixed and accurate.
  2. Ensure all terminations are tight.
  3. Check sensor placement is adequate for required duty.
  4. Ensure adequate access is provided to all relays/contactors, timeclocks, etc.
  5. Ensure all circuits for the loads are energized and ready for testing.
  6. Obtain all time schedules and individual device time-delay settings for all spaces from the Owner.
- D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
1. Test, calibrate, and set all sensing (photocells, motion sensors, etc.) devices.
  2. Verify the correct operation of all control devices (contactors, relays, timeclocks, BAS interface relays, etc.).



3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
  4. Check full load current on all control device contacts serving controlled lighting to ensure that the contact rating is properly sized.
  5. Enter all time schedules per Owner's direction. Individual device time-delay settings are handled as part of the Room/Zone Checkout described in this Section.
  6. Validate all interfaces with other systems on a point-by-point basis.
- E. Training: Train Owner's maintenance personnel on the operation, programming and maintenance of the lighting controls.

### 3.8 INTEGRATED LIGHTING CONTROL SYSTEMS

- A. Include all applicable 'Start-Up Checks Common to All Systems'. Additional Start-Up Checks and Tests are as follows.
- B. General: Provide the services of a factory-trained manufacturer's representative to assist the Contractor in the installation and start-up service of the lighting control system and train Owner's maintenance personnel as specified below. Representative will confirm the proper installation and operation of all system components. Refer to the quality control requirements listed in applicable sections of Division 26 for additional checks and tests. These shall be included in the Start-Up Checks and Tests used for this project.
- C. Start-Up Checks: During start-up, perform the following checks and any additional checks specified in manufacturer's instructions.
1. Ensure all labeling is affixed and accurate.
  2. Ensure all terminations are tight.
  3. Check sensor placement is adequate for required duty.
  4. Ensure adequate access is provided to all panels and that documentation of that panel is provided in it.
  5. Ensure all circuits for the loads are energized and ready for testing.
  6. Obtain all time schedules, individual device time-delay settings for all spaces, and on/off fade-rate settings from the Owner.
- D. Start-Up Tests: During start-up, perform the following tests, measurements, or procedures and any additional tests, measurements, or procedures specified in manufacturer's instructions.
1. Test, calibrate, and set all digital and analog sensing, and actuating devices. Calibrate each instrumentation device by making a comparison between the graphic display and the reading at the device, using an instrument traceable to the National Bureau of Standards, which shall be at least twice as accurate as the device to be calibrated (e.g., if field device is  $\pm 0.5\%$  accurate, test equipment shall be  $\pm 0.25\%$  accurate over same range). Record the measured value and displayed value for each device in the Start-Up Report.
  2. Check each digital control point by making a comparison between the control command at the control panel and the status of the controlled device. Check each digital input point by making a comparison of the state of the sensing device and the display. Record the results for each device in the BAS Start-Up Report.
  3. Check full load current on all breakers serving controlled lighting to ensure that the breaker is properly sized.
  4. Check full load current on all control device contacts serving controlled lighting to ensure that the

- contact rating is properly sized.
- 5. Enter all time schedules, override time-delays and on/off fade rates per Owner's direction.
- 6. For Operator Interfaces:
  - a. Verify all elements on the graphics are functional and properly bound to physical devices and/or virtual points and that hot links or page jumps are functional and logical.
  - b. Output all specified reports for review and approval.
  - c. Verify the alarm printing and logging is functional and per requirements.
- 7. Validate all interfaces with other systems on a point-by-point basis.
- E. Training: Train Owner's maintenance personnel on the operation and programming of the lighting control system.

END OF SECTION 26 08 00