

Delaware Army National Guard Readiness Center
DEARNG #20017-RRTSRCCONS; NGB #100093

Addendum 5
August 31, 2023

1. Bidder Questions and Answers. (attached)
2. The Project Manual is amended in accordance with Amendment No. 3 (attached)
3. For the drawings indicated in the table below, replace the previous issued drawings with revised drawings. Use this link to access: [DEARNG RRTS Readiness Center Addendum 5 Const Dwgs](#)

Drawing	Title	Rev	Date
G-000	COVER SHEET	3	08/31/23
C-106	SITE LAYOUT PLAN	2	08/31/23
A-401	RESTROOM PLANS, DETAILS & ELEVATIONS	3	08/31/23
A-402	ENLARGED RESTROOMS PLANS & ELEVATIONS	3	08/31/23
A-505	INTERIOR DETAILS	3	08/31/23
A-601	DOOR & WINDOW SCHEDULES	3	08/31/23
A-602	FINISH SCHEDULES	3	08/31/23

Attachments:

1. Bidder Questions and Answers.
2. Amendment #3.

John Sclesky, PE



Century Engineering, LLC

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BIDDER QUESTIONS AND ANSWERS

Q1: Drawing E-602; Low Voltage Systems – Distribution of Responsibility Access Control System.

On the Drawing it states Owner is to furnish and install head end equipment. Owner is providing Peripheral equipment. Contractor to install owner provided devices and provide / install cabling from the devices back to the MDF/IDF. Please clarify Manufacturer, Model Number, and Quantity of all equipment owner is providing for the Access Control System for the contractor to install.

A1: The rack is APC AR3100 (This is to be contractor provided). Termination is 48 patch panel for CAT 6 cables.

Q2: Detail No. 4 Access Control System Riser on Drawing E-602: Please clarify cable type to be installed from the MDF/IDF on the right side of detail to each device shown on left side of detail.

A2: This cable shall be per manufacturer requirements.

Q3: Drawing E-001 – Access Control and Detection Systems Symbols: Please clarify cable type for each device contractor is to provide and rough in back to the MDF/IDF.

A3: CAT 6 – white jacket.

Q4: Detail No. 1 Telecommunications Riser on Drawing E-602: Tie cables indicated between IT109 and IT146 state for coax, 6 pair UTP, 6 strand multimode fiber, and 6 strand singlemode fiber. In Spec section 270500 2.1 C. 1. F. it states 62.5 fiber or OM1. Does owner want 62.5 OM1 installed or OM4? Also State of DE Standard is 12 strands of singlemode, does owner want 12 strands of both singlemode and multimode installed?

A4: All fiber cable to be singlemode, OM1.

Q5: The State of Delaware requires that their owned or managed facilities have their Structured Communications Cabling installed by an Approved Cabling Vendor with the State of Delaware Cabling Contract GSS21441-DATA_CBL and the System installed be compliant with the State of Delaware DTI Structured Cabling System Standards and Specifications for State Managed Facilities. Do these State of Delaware requirements apply to this project?

A5: No. DEARNG manages the structured communications.

Q6: Drawing E-001 – Wifi Access Point Symbol – it states provide cat 6 cabling. Please clarify if one or two cables are to be pulled to each WAP. Does the owner want Category 6A cabling to be installed for WAP outlet locations?

A6: Use CAT 6 as currently specified. (2) cables to each WAP.

Q7: Drawing E-002 – Site Drawing – CMH-11A is stated as having existing coiled comm cabling to be pulled to MDF Rm 109. If contractor is responsible for anything more than pulling these cables to that room, such as terminations or testing; please clarify. If termination and testing are required, please clarify specific existing cable types that are to be pulled to the MDF etc...

A7: Drawing E-301 note at Bottom left of sheet details requirement for testing integrity and terminating cables.

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Q8: Bid Form – Unit Price No. 1: is the 12 strand MM fiber to be OM1 or OM4? Is this unit price to assume the application is in conduit and below grade?

A8: The unit priced item shall be for 12 strand single mode (SM 1) OM1. Conduit between MDF and IDF is currently shown as below slab. Overhead run via cable tray would also be acceptable.

Q9: Please extend the bid due date to 9/21/23 to fit in with the manufacturers and subcontractors' bid schedules to ensure proper subcontractor coverage.

A9: The bid due date has been extended to 9/18/2023; 2pm. The bid due date will not be extended beyond this date.

Q10: Will this project need to be in compliance with the Delaware Apprenticeship program?

A10: Yes.

Q11: Is the project Tax Exempt for materials installed that will remain permanently in place on the project?

A11: No

Q12: Who is responsible for testing & inspections?

A12: The contractor is responsible for testing and inspections in accordance with project manual requirements.

Q13: Please provide the location to cap the gas line if Alternate 4 emergency generator is not awarded.

A13: Terminate gas line at the proposed generator location.

Q14: Are FFE items to be included in base bid? If so, please list what items are to be considered FFE and provide as an allowance amount for fair and equitable bidding?

A14: For FFE items which are by the Government see A-602- "Furniture & Equipment Schedule (NIC-For Information Only)". All other items on the drawings and specifications are to be provided by the Contractor.

Q15: Does the FFE installer do the final connections for voice, data, and power for FFE and AV bid options in their scope provided to government?

A15: Yes.

Q16: Please clarify what pricing is to be included in Alternate 8 – Kitchen Equipment. Appendix 8 Note 1 states that the Kitchen Equipment is to be furnished by the Government.

A16: Include all utility rough-in and equipment installation and start-up.

Q17: Plan A-411 has a schedule of Kitchen Equipment with note #1 listing that all kitchen equipment is to be provided by the Government. Please confirm the items noted in base bid are also furnished by the Government.

A17: Sheet A-411 is the Base Bid Kitchen Design. Sheet A-702 is the Alternate #8 Kitchen Design. In each case, note #1 states "All kitchen equipment to be provided by Government and installed by Contractor.

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Q18: Please clarify Alternate 8, if awarded, will be awarded at the same time as base bid.

A18: Alternates will be determined at the time of award.

Q19: Will the Alternate 8 pricing need to include pricing to demo any installed slab on grade if awarded after slab installation?

A19: Alternates will be determined at the time of award.

Q20: Additional time will be required to perform the alternates, please clarify how much additional time will be allocated per alternate.

A20: Performance period is based on the award of all alternates.

Q21: Can the subcontractor listing be submitted a day after bid due date? Many of the subcontractors will not send in quotes until minutes before the formal bid time. This does not allow for adequate time to fill out the subcontractor listing properly.

A21: No.

Q22: Can the Superintendent perform the duties of quality control manager or safety officer concurrently with the duties of Superintendent? Or are there to be three individuals to perform each duty?

A22: No. Three individuals are required to perform each duty.

Q23: After the award, the Contracting Officer will provide a NTP to the awardee. What is the approximate duration between issuing the award and issuing the NTP?

A23: There will be a 2–3-week period to review for award. NTP is expected to be issued approximately 1-2 weeks after award.

Q24: Confirm who the vendor is that currently services Fire Alarm system at this facility.

A24: Premium Fire and Security LLC.

Q25: Confirm who the vendor is that currently services Security system at this facility.

A25: Advantech.

Q26: Confirm who the vendor is that currently services Telecom system at this facility.

A26: Delaware Army National Guard.

Q27: On page A-602, epoxy flooring EP-1 is indicated in several locations. We were not able to find the specification requirements for EP-1. Please provide a specification section for the epoxy flooring.

A27: See new specification section 09 67 23 Resinous Flooring.

Q28: Please confirm there is no sales tax and the State of Delaware Excise Tax would be all that applies.

A28: Not applicable.

Q29: Please consider removing the requirement for Title 29, Chapter 69, Section 6962(c)(13) of the Delaware Code. This could add significant cost to the overall project.

A29: This requirement cannot be removed.

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Q30: Are there any Buy American requirements for this project?

A30: Yes.

Q31: If there are Buy American requirements, we will need the statute that we need to adhere to for the Buy American (STAA? BAA? ARRA? Etc.)

A31: All buy American statutes are applicable.

Q32: Please confirm there are no US Citizen only requirements.

A32: Security protocol requires that all contractor personnel must have a SSN and complete/pass a security background check to enter the River Road Training Site.

Q33: Please confirm factory mutual stamp is not required.

A33: Confirmed. Factory Mutual Stamp is not required.

Q34: Will alternate be awarded along with the base bid or should re-work be priced into the alternates?

A34: Alternates will be determined at the time of award.

Q35: Will the contractor be responsible for the chemicals in the controlled waste and flammable storage facilities prior to their move.

A35: No.

Q36: Please provide a list of chemicals in the controlled waste facility and the flammable storage facility.

A36: Only cleaning and petroleum products are expected.

Q37: Please provide requirements for remediation of chemicals in the controlled waste facility.

A37: No interior remediation is required.

Q38: Please clarify the enclosure around the GENSET on page C-106. It appears to be called out with the incorrect drawing note.

A37: Note 24 – new concrete retaining wall that references typical retaining wall section drawing sheet C-110 has been added.

Q39: Is the enclosure around the GENSET to be included in the generator alternate price or in the base bid.

A39: Include in the Base Bid.

Q40: Should the concrete pad for the GENSET be included in the generator alternate price or in the base bid?

A40: Include in the Base Bid.

Q41: What is the substrate for Alternate #5?

A41: Manufactured Stone Veneer (Alternate #5) shall be installed over standard gray block CMU.

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Q42: The details for Alternate #5 show both the base bid veneer and the alternate #5 veneer. Should the Alternate #5 veneer be installed on top of the base bid veneer?

A42: Manufactured Stone Veneer (Alternate #5) shall be installed over standard gray block CMU.

Q43: Please confirm rough ins for equipment listed in Alternate # 8 are not included in base bid.

A43: Confirmed.

Q44: Are there small business participation goals?

A44: Small business participation is encouraged but there are no specific goals.

Q45: There are conflicting notes of C-100 to either remove spoils or keep them on site. Demolition notes 2 & 6. Which is correct?

A45: Note 2 excludes soils. Excess soil is expected to remain on site. Debris such as pipe, concrete, masonry, conduit, etc. is expected to be legally disposed of off-site.

Q46: What are contractors to hold as an allowance for existing foundations possibly uncovered in excavation operations per C-100 demolition note 7?

A46: No allowance is permitted.

Q47: Please confirm the main frame lateral drift of prefab metal building is 1/200 of building height.

A47: Confirmed. Main frame lateral drift is 1/200 of building height.

Q48: Please confirm if Door Type 147A KITCHEN F WD 6' - 0" 7' - 0" 1 3/4" is a single door (Door Type F) per Door Schedule A-601. Door Size indicates the use of a double door- (Door type FF).

A48: Door 147A Lockers is Elevation FF.

Q49: Please confirm if Door Type 110 LOCKERS F HM/EHD 6' - 0" 7' - 0" 1 3/4" 1 is a single door (Door Type F) per Door Schedule A-601. Door size indicates the use of a double door- (Door type FF).

A49: Door 147A Lockers is Elevation FF.

Q50: Please advise, Door type HL is noted on Door Schedule A-601 for 134 BREAK/VENDING HL WD 3' - 0" 7' - 0" 1 3/4", should this be NL?

A50: Door 134 Break/Vending is Elevation HG.

Q51: Please confirm if GC to Furnish and Install Fire Extinguishers. Per Furniture & Equipment Schedule on Plan page A-602 notes by others. Specification section 10 44 16-2 notes provide and install as indicated on the drawings.

A51: No. The fire extinguishers will be furnished/installed via DEARNG.

Q52: Please clarify Millwork Schedule on Plan Page A-602. MW-2 is noted twice, should one of these be a different Millwork type?

A52: MW-2 is a duplicate and is not a mismarked item.

AMENDMENT NO. 3

The Project Manual is amended as follows:

1. Specification Section 00 01 10 TABLE OF CONTENTS. Remove previous specification section (Reference Addendum 2) in its entirety and replace with the revised section. Attached.
2. Add Specification section 01 91 13 FL – General Commissioning Requirements. Attached.
3. Add Specification section 01 91 19.43 – Exterior Enclosure Commissioning. Attached.
4. Add Specification section 22 08 00 – Commissioning of Plumbing. Attached.
5. Add Specification section 23 08 00 - Commissioning of HVAC. Attached.
6. Add Specification section 26 08 00 - Commissioning of Electrical Systems. Attached.
7. Specification section 09 30 13 – Ceramic Tiling. Modified to include cement backer units at all CMU partitions receiving ceramic tile. Attached.
8. Add new specification section 09 76 23 – Resinous Flooring. Attached.

End of Amendment No. 3

SECTION 00 01 10 – TABLE OF CONTENTS

A. Specifications for this project are arranged in accordance with the Construction Specification Institute numbering system and format. Section numbering is discontinuous and all numbers not appearing in the Table of Contents are not used for this Project.

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REFERENCED STANDARDS

DELAWARE DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION (JUNE 2022, OR MOST CURRENT AT THE DATE OF ADVERTISEMENT)

NOTE: Provisions within the referenced specification sections regarding material and execution requirements are applicable. The provisions regarding DelDOT provided services including survey, testing, inspection, measurement, payment or other services are not applicable.

SECTION 201 – CLEARING AND GRUBBING
SECTION 202 – EXCAVATION AND EMBANKMENT
SECTION 207 – STRUCTURAL EXCAVATION AND BACKFILLING
SECTION 209 – BORROW
SECTION 211 – REMOVAL OF STRUCTURES AND OBSTRUCTIONS
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**STATE OF DELAWARE DEPARTMENT OF NATURAL RESOURCES AND
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SECTION 019113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and other Division 01 Specification Sections, apply to this Section.
- B. Owner's Project Requirements and Basis-of-Design Document are included by reference for information only.

1.2 SUMMARY

A. Section Includes:

- 1. General requirements for coordinating and scheduling commissioning activities.
- 2. Commissioning meetings.
- 3. Commissioning reports.
- 4. Use of commissioning process test equipment, instrumentation, and tools.
- 5. Construction checklists, including, but not limited to, installation checks, startup, performance tests, and performance test demonstration.
- 6. Commissioning tests and commissioning test demonstration.
- 7. Adjusting, verifying, and documenting identified systems and assemblies.

B. Related Requirements:

- 1. Section 011100 "Summary of Work."
- 2. Section 013300 "Submittal Procedures" for submittal procedure requirements for commissioning process.
- 3. Section 017700 "Closeout Procedures" for Certificate of Construction-Phase Commissioning Process Completion submittal requirements.
- 4. Section 017823 "Operation and Maintenance Data" for preliminary operation and maintenance data submittal requirements.
- 5. Section 019119.43 "Exterior Enclosure Commissioning" for technical commissioning requirements for exterior closure.
- 6. Section 220800 "Commissioning of Plumbing" for technical commissioning requirements for plumbing.
- 7. Section 230800 "Commissioning of HVAC" for technical commissioning requirements for HVAC.
- 8. Section 260800 "Commissioning of Electrical Systems" for technical commissioning requirements for electrical systems.

C. Systems to Be Commissioned

- 1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and passive) and associated controls.

2. Air-curtain systems
3. Lighting systems, automatic and manual daylighting controls, occupancy sensing devices, automatic shut-off controls, time switching, and other lighting control devices, and dimming systems.
4. Domestic hot water systems and controls
5. Energy and building management and demand-control systems
6. Building envelope and assemblies, including thermal and moisture integrity and pressurization / air -tightness
7. Building Automation Systems (BAS)
8. Meters and Sub-meters (water and energy measurement devices)
9. Building Envelope: air tightness for the entire building envelope (systems, components, and assemblies).

1.3 DEFINITIONS

- A. Acceptance Criteria: Threshold of acceptable work quality or performance specified for a commissioning activity, including, but not limited to, construction checklists, performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.
- B. Basis-of-Design Document: A document prepared by Architect that records concepts, calculations, decisions, and product selections used to comply with Owner's Project Requirements and to suit applicable regulatory requirements, standards, and guidelines.
- C. Commissioning Authority: An entity engaged by Owner, and identified in Section 011100 "Summary of Work," to evaluate Commissioning-Process Work.
- D. Commissioning Plan: A document, prepared by Commissioning Authority, that outlines the organization, schedule, allocation of resources, and documentation of commissioning requirements.
- E. Commissioning: A quality-focused process for verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, and tested to comply with Owner's Project Requirements. The requirements specified here are limited to the construction phase commissioning activities. The scope of the commissioning process is defined in Section 011100 "Summary of Work."
- F. Construction-Phase Commissioning-Process Completion: The stage of completion and acceptance of commissioning process when resolution of deficient conditions and issues discovered during commissioning process and retesting until acceptable results are obtained has been accomplished. Owner will establish in writing the date construction-phase commissioning-process completion is achieved. See Section 017700 "Closeout Procedures" for Certificate of Construction-Phase Commissioning Process Completion submittal requirements.
 1. Commissioning process is complete when the Work specified of this Section and related Sections has been completed and accepted, including, but not limited to, the following:
 - a. Completion of tests and acceptance of test results.
 - b. Resolution of issues, as verified by retests performed and documented with acceptance of retest results.
 - c. Comply with requirements in Section 017900 "Demonstration and Training."

d. Completion and acceptance of submittals and reports.

- G. Owner's Project Requirements: A document that details the functional requirements of a project and the expectations of how it will be used and operated, including Project goals, measurable performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This document is prepared either by the Owner or for the Owner by the Architect or Commissioning Authority.
- H. Owner's Witness: Commissioning Authority, Owner's Project Manager, or Architect-designated witness authorized to authenticate test demonstration data and to sign completed test data forms.
- I. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.
- J. Test: Performance tests, performance test demonstrations, commissioning tests, and commissioning test demonstrations.
- K. Sampling Procedures and Tables for Inspection by Attributes: As defined in ASQ Z1.4.

1.4 COMPENSATION

- A. If Architect, Commissioning Authority, other Owner's witness, or Owner's staff perform additional services or incur additional expenses due to actions of Contractor listed below, compensate Owner for such additional services and expenses.
 - 1. Failure to provide timely notice of commissioning activities schedule changes.
 - 2. Failure to meet acceptance criteria for test demonstrations.
- B. Contractor shall compensate Owner for such additional services and expenses at the rate of \$200 per labor hour, plus \$100 per round trip for personnel travelling more than 50 miles, plus per diem allowances for meals and lodging according to current U.S. General Services Administration (GSA) Per Diem Rates.

1.5 COMMISSIONING TEAM

- A. Members Appointed by Contractor(s):
 - 1. Commissioning Coordinator: A person or entity employed by Contractor to manage, schedule, and coordinate commissioning process.
 - 2. Project superintendent and other employees that Contractor may deem appropriate for a particular portion of the commissioning process.
 - 3. Subcontractors, installers, suppliers, and specialists that Contractor may deem appropriate for a particular portion of the commissioning process.
 - 4. Appointed team members shall have the authority to act on behalf of the entity they represent.
- B. Members Appointed by Owner:

1. Commissioning Authority, plus consultants that Commissioning Authority may deem appropriate for a particular portion of the commissioning process.
2. Owner representative(s), facility operations and maintenance personnel, plus other employees, separate contractors, and consultants that Owner may deem appropriate for a particular portion of the commissioning process.
3. Architect, plus employees and consultants that Architect may deem appropriate for a particular portion of the commissioning process.

1.6 INFORMATIONAL SUBMITTALS

- A. Comply with requirements in Section 013300 "Submittal Procedures" for submittal procedure general requirements for commissioning process.
- B. Commissioning Plan Information:
 1. List of Contractor-appointed commissioning team members to include specific personnel and subcontractors performing the various commissioning requirements.
 2. Schedule of commissioning activities, integrated with the Construction Schedule. Comply with requirements in Section 013200 "Construction Progress Documentation" for the Construction Schedule general requirements for commissioning process.
 3. Contractor personnel and subcontractors participating in each test.
 4. List of instrumentation required for each test to include identification of parties that will provide instrumentation for each test.
- C. Commissioning schedule.
- D. Two-week look-ahead schedules.
- E. Commissioning Coordinator Letter of Authority:
 1. Within 10 days after approval of Commissioning Coordinator qualifications, submit a letter of authority for Commissioning Coordinator, signed by a principal of Contractor's firm. Letter shall authorize Commissioning Coordinator to do the following:
 - a. Make inspections required for commissioning process.
 - b. Coordinate, schedule, and manage commissioning process of Contractor, subcontractors, and suppliers.
 - c. Obtain documentation required for commissioning process from Contractor, subcontractors, and suppliers.
 - d. Report issues, delayed resolution of issues, schedule conflicts, and lack of cooperation or expertise on the part of members of the commissioning team.
- F. Commissioning Coordinator Qualification Data: For entity coordinating Contractor's commissioning activities to demonstrate their capabilities and experience.
 1. Experienced: When used with an entity or individual, "experienced" means having successfully completed a minimum of three previous projects similar in nature, size, and extent to this Project; being familiar with special requirements indicated; and having complied with requirements of authorities having jurisdiction.

G. List test instrumentation, equipment, and monitoring devices. Include the following information:

1. Make, model, serial number, and application for each instrument, equipment, and monitoring device.
2. Brief description of intended use.
3. Calibration record showing the following:
 - a. Calibration agency, including name and contact information.
 - b. Last date of calibration.
 - c. Range of values for which calibration is valid.
 - d. Certification of accuracy.
 - e. Certification for calibration equipment traceable to NIST.
 - f. Due date of the next calibration.

H. Test Reports:

1. Pre-Startup Report: Prior to startup of equipment or a system, submit signed, completed construction checklists.
2. Test Data Reports: At the end of each day in which tests are conducted, submit test data for tests performed.
3. Commissioning Issue Reports: Daily, at the end of each day in which tests are conducted, submit commissioning issue reports for tests for which acceptable results were not achieved.
4. Weekly Progress Report: Weekly, at the end of each week in which tests are conducted, submit a progress report.
5. Data Trend Logs: Submit data trend logs at the end of the trend log period.
6. System Alarm Logs: Daily, at the start of days following a day in which tests were performed, submit printout of log of alarms that occurred since the last log was printed.

I. Construction Checklists:

1. Material checks.
2. Installation checks.
3. Startup procedures, where required.

1.7 CLOSEOUT SUBMITTALS

A. Commissioning Report:

1. At Construction-Phase Commissioning Completion, include the following:
 - a. Pre-functional checklist (PFC) reports.
 - b. Approved test procedures.
 - c. System verification checklists (SVC), completed and signed.
 - d. Progress reports.
 - e. Commissioning issue report log.
 - f. Commissioning issue reports showing resolution of issues.
 - g. Correspondence or other documents related to resolution of issues.
 - h. Other reports required by commissioning process.

- i. List unresolved issues and reasons they remain unresolved and should be exempted from the requirements for Construction-Phase Commissioning Completion.
 - j. Report shall include commissioning work of Contractor.
- B. Request for Certificate of Construction-Phase Commissioning Process Completion.
- C. Operation and Maintenance Data: For proprietary test equipment, instrumentation, and tools to include in operation and maintenance manuals.

1.8 QUALITY ASSURANCE

- A. Commissioning Coordinator Qualifications:
 - 1. Documented experience commissioning systems of similar complexity to those contained in these documents on at least three projects of similar scope and complexity.
 - 2. Certification of commissioning-process expertise. The following certifications are acceptable. Owner reserves the right to accept or reject certifications as evidence of qualification.
 - a. Certified Commissioning Authority, by AABC Commissioning Group (ACG).
 - b. Commissioning-Process Management Professional, by American Society of Heating, Refrigerating and Air-Conditioning Engineers.
- B. Calibration Agency Qualifications: Certified by The American Association for Laboratory Accreditation that the calibration agency complies with minimum requirements of ISO/IEC 17025.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

- A. Test equipment and instrumentation required to perform the commissioning process shall remain the property of Contractor unless otherwise indicated.
- B. Test equipment and instrumentation required to perform commissioning process shall comply with the following criteria:
 - 1. Be manufactured for the purpose of testing and measuring tests for which they are being used and have an accuracy to test and measure system performance within the tolerances required to determine acceptable performance.
 - 2. Calibrated and certified.
 - a. Calibration performed and documented by a qualified calibration agency according to national standards applicable to the tools and instrumentation being calibrated. Calibration shall be current according to national standards or within test equipment and instrumentation manufacturer's recommended intervals, whichever is more frequent, but not less than within six months of initial use on Project. Calibration tags shall be permanently affixed.

- b. Repair and recalibrate test equipment and instrumentation if dismantled, dropped, or damaged since last calibrated.
- 3. Maintain test equipment and instrumentation.
- 4. Use test equipment and instrumentation only for testing or monitoring Work for which they are designed.

2.2 PROPRIETARY TEST EQUIPMENT, INSTRUMENTATION, AND TOOLS

- A. Proprietary test equipment, instrumentation, and tools are those manufactured or prescribed by tested equipment manufacturer and required for work on its equipment as a condition of equipment warranty, or as otherwise required to service, repair, adjust, calibrate, or perform work on its equipment.
 - 1. Identify proprietary test equipment, instrumentation, and tools required in the test equipment identification list submittal.
 - 2. Proprietary test equipment, instrumentation, and tools shall become the property of Owner at Substantial Completion.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Review preliminary construction checklists and preliminary test procedures and data forms.

3.2 CONSTRUCTION CHECKLISTS

- A. Construction checklists cannot modify or conflict with the Contract Documents.
- B. Create construction checklists based on actual systems and equipment to be included in Project.
- C. Material Checks: Compare specified characteristics and approved submittals with materials as received. Include factory tests and other evaluations, adjustments, and tests performed prior to shipment if applicable.
 - 1. Service connection requirements, including configuration, size, location, and other pertinent characteristics.
 - 2. Included optional features.
 - 3. Delivery Receipt Check: Inspect and record physical condition of materials and equipment on delivery to Project site, including agreement with approved submittals, cleanliness, and lack of damage.
 - 4. Installation Checks:
 - a. Location according to Drawings and approved Shop Drawings.
 - b. Configuration.
 - c. Compliance with manufacturers' written installation instructions.
 - d. Attachment to structure.

- e. Access clearance to allow for maintenance, service, repair, removal, and replacement without the need to disassemble or remove other equipment or building elements. Access coordinated with other building elements and equipment, including, but not limited to, ceiling and wall access panels, in a manner consistent with OSHA fall-protection regulations and safe work practices.
 - f. Utility connections are of the correct characteristics, as applicable.
 - g. Correct labeling and identification.
 - h. Startup Checks: Verify readiness of equipment to be energized. Include manufacturer's standard startup procedures and forms.
- D. Startup: Perform and document initial operation of equipment to prove that it is installed properly and operates as intended according to manufacturer's standard startup procedures, at minimum.
- E. Performance Tests:
 - 1. Static Tests: As specified elsewhere, including, but not limited to, duct and pipe leakage tests, insulation-resistance tests, and water-penetration tests.
 - 2. Component Performance Tests: Tests evaluate the performance of an input or output of components under a full range of operating conditions.
 - 3. Equipment and Assembly Performance Tests: Test and evaluate performance of equipment and assemblies under a full range of operating conditions and loads.
 - 4. System Performance Tests: Test and evaluate performance of systems under a full range of operating conditions and loads.
 - 5. Intersystem Performance Tests: Test and evaluate the interface of different systems under a full range of operating conditions and loads.
- F. Deferred Construction Checklists: Obtain Owner approval of proposed deferral of construction checklists, including proposed schedule of completion of each deferred construction checklist, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. When approved, deferred construction checklists may be completed after date of Construction-Phase Commissioning Completion. Include the following in a request for Certificate of Construction-Phase Commissioning Process Completion:
 - 1. Identify deferred construction checklists by number and title.
 - 2. Provide a target schedule for completion of deferred construction checklists.
 - 3. Written approval of proposed deferred construction checklists, including approved schedule of completion of each deferred construction checklist.
- G. Delayed Construction Checklists: Obtain Owner approval of proposed delayed construction checklists, including proposed schedule of completion of each delayed construction checklist, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. When approved, delayed construction checklists may be completed after date of Construction-Phase Commissioning Completion. Include the following in a request for Certificate of Construction-Phase Commissioning Process Completion:
 - 1. Identify delayed construction checklist by construction checklist number and title.
 - 2. Provide a target schedule for completion of delayed construction checklists.
 - 3. Written approval of proposed delayed construction checklists, including approved schedule of completion of each delayed construction checklist.

3.3 GENERAL EXECUTION REQUIREMENTS

- A. Schedule and coordinate commissioning process with the Construction Schedule.
- B. Perform activities identified in construction checklists, including tests, and document results of actions as construction proceeds.
- C. Perform test demonstrations for Owner's witness. Unless otherwise indicated, demonstrate tests for 100 percent of work to which the test applies. In some instances, demonstration of a random sample of other than 100 percent of the results of a test is specified.
 - 1. Where sampling is specified, the sampling plan and procedure for the test demonstration shall be determined using ASQ Z1.4.
 - a. General Inspection: Level I.
 - b. Special Inspection: Level S-1.
 - c. Acceptance Quality Limit (AQL) of 1.5.
 - 2. The "lot size" in ASQ Z1.4 is the sum of the number of items to which the test demonstration applies, as described in the scope subparagraph of each test.
 - 3. On determination of the sample size, the samples shall be selected randomly by Owner's witness at the time of the test demonstration.
- D. Report test data and commissioning issue resolutions.
- E. Schedule personnel to participate in and perform Commissioning-Process Work.
- F. Installing contractors' commissioning responsibilities include, but are not limited to, the following:
 - 1. Operating the equipment and systems they install during tests.
 - 2. In addition, installing contractors may be required to assist in tests of equipment and systems with which their work interfaces.

3.4 COMMISSIONING COORDINATOR RESPONSIBILITIES

- A. Management and Coordination: Manage, schedule, and coordinate commissioning process, including, but not limited to, the following:
 - 1. Coordinate with subcontractors on their commissioning responsibilities and activities.
 - 2. Obtain, assemble, and submit commissioning documentation.
 - 3. Attend periodic on-site commissioning meetings. Comply with requirements in Section 013100 "Project Management and Coordination."
 - 4. Develop and maintain the commissioning schedule. Integrate commissioning schedule into the Construction Schedule. Update Construction Schedule at specified intervals.
 - 5. Review and comment on preliminary test procedures and data forms.
 - 6. Report inconsistencies and issues in system operations.
 - 7. Verify that tests have been completed and results comply with acceptance criteria, and that equipment and systems are ready before scheduling test demonstrations.
 - 8. Direct and coordinate test demonstrations.

9. Coordinate witnessing of test demonstrations by Owner's witness.
10. Coordinate and manage training. Be present during training sessions to direct video recording, present training, and direct the training presentations of others. Comply with requirements in Section 017900 "Demonstration and Training."
11. Prepare and submit specified commissioning reports.
12. Track commissioning issues until resolution and retesting is successfully completed.
13. Retain original records of Commissioning-Process Work, organized as required for the commissioning report. Provide Owner's representative access to these records on request.

3.5 COMMISSIONING TESTING

- A. Quality Control: Construction checklists, including tests, are quality-control tools designed to improve the functional quality of Project. Test demonstrations evaluate the effectiveness of Contractor's quality-control process.
- B. Owner's witness will be present to witness commissioning work requiring the signature of an owner's witness, including, but not limited to, test demonstrations. Owner's project manager will coordinate attendance by Owner's witness with Contractor's published Commissioning Schedule. Owner's witness will provide no labor or materials in the commissioning work. The only function of Owner's witness will be to observe and comment on the progress and results of commissioning process.
- C. Construction Checklists:
 1. Complete construction checklists electronically via Facility Grid web-based software as Work is completed.
 2. Distribute construction checklists to installing contractors before they start work.
 3. Installers:
 - a. Verify installation using approved construction checklists as Work proceeds.
 - b. Utilizing Facility Grid, complete and sign construction checklists weekly for work performed during the preceding week.
 4. Record progress on construction checklists on Facility Grid web-based software.
- D. Installation Compliance Issues: Record via Facility Grid web-based software as an installation compliance issue Work found to be incomplete, inaccessible, at variance with the Contract Documents, nonfunctional, or that does not comply with construction checklists. Record installation compliance issues on the construction checklist at the time they are identified. Record corrective action and how future Work should be modified before signing off the construction checklist.
- E. Pre-Startup Audit: Prior to executing startup procedures, review completed installation checks to determine readiness for startup and operation. Report conditions via Facility Grid web-based software, which, if left uncorrected, adversely impact the ability of systems or equipment to operate satisfactorily or to comply with acceptance criteria. Complete pre-startup report for each system.
- F. Test Procedures and Test Data Forms:

1. Test procedures shall define the step-by-step procedures to be used to execute tests and test demonstrations.
2. Test procedures shall be specific to the make, model, and application of the equipment and systems being tested.
3. Completed test data forms are the official records of the test results.
4. Commissioning Authority will provide to Contractor preliminary test procedures and test data forms for performance tests and commissioning tests after approval of Product Data, Shop Drawings, and preliminary operation and maintenance manual.
5. Review preliminary test procedures and test data forms, and provide comments within 14 days of receipt from Commissioning Authority. Review shall address the following:
 - a. Equipment protection and warranty issues, including, but not limited to, manufacturers' installation and startup recommendations, and operation and maintenance instructions.
 - b. Applicability of the procedure to the specific software, equipment, and systems approved for installation.
6. After Contractor has reviewed and commented on the preliminary test procedures and test data forms, Commissioning Authority will revise and reissue the approved revised test procedures and test data forms marked "Approved for Testing."
7. Use only approved test procedures and test data forms marked "Approved for Testing" to perform and document tests and test demonstrations.

G. Performance of Tests:

1. The sampling rate for tests is 100 percent. The sampling rate for test demonstrations is 100 percent unless otherwise indicated.
2. Perform and complete each step of the approved test procedures in the order listed.
3. Record data observed during performance of tests on approved data forms at the time of test performance and when the results are observed.
4. Record test results that are not within the range of acceptable results on commissioning issue report forms in addition to recording the results on approved test procedures and data forms according to the "Commissioning Compliance Issues" Paragraph in this Article.
5. On completion of a test, sign the completed test procedure and data form. Tests for which test procedures and data forms are incomplete, not signed, or which indicate performance that does not comply with acceptance criteria will be rejected. Tests for which test procedures and data forms are rejected shall be repeated and results resubmitted.

H. Performance of Test Demonstration:

1. Perform test demonstrations on a sample of tests after test data submittals are approved. The sampling rate for test demonstrations shall be 100 percent unless otherwise indicated in the individual test specification.
2. Notify Owner's witness at least three days in advance of each test demonstration.
3. Perform and complete each step of the approved test procedures in the order listed.
4. Record data observed during performance of test demonstrations on approved data forms at the time of demonstration and when the results are observed.
5. Provide full access to Owner's witness to directly observe the performance of all aspects of system response during the test demonstration. On completion of a test demonstration,

- sign the completed data form and obtain signature of Owner's witness at the time of the test to authenticate the reported results.
6. Test demonstration data forms not signed by Contractor and Owner's witness at the time of the completion of the procedure will be rejected. Test demonstrations for which data forms are rejected shall be repeated and results shall be resubmitted.
 - a. Exception for Failure of Owner's Witness to Attend: Failure of Owner's witness to be present for agreed-on schedule of test demonstration shall not delay Contractor. If Owner's witness fails to attend a scheduled test, Contractor shall proceed with the scheduled test. On completion, Contractor shall sign the data form for Contractor and for Owner's witness, and shall note the absence of Owner's witness at the scheduled time and place.
 7. False load test requirements are specified in related sections.
 - a. Where false load testing is specified, provide temporary equipment, power, controls, wiring, piping, valves, and other necessary equipment and connections required to apply the specified load to the system. False load system shall be capable of steady-state operation and modulation at the level of load specified. Equipment and systems permanently installed in this work shall not be used to create the false load without Architect's written approval.
- I. Deferred Tests:
1. Deferred Test List: Identify, in the request for Certificate of Construction-Phase Commissioning Process Completion, proposed deferred tests or other tests approved for deferral until specified seasonal or other conditions are available. When approved, deferred tests may be completed after the date of Construction-Phase Commissioning Completion. Identify proposed deferred tests in the request for Certificate of Construction-Phase Commissioning Process Completion as follows:
 - a. Identify deferred tests by number and title.
 - b. Provide a target schedule for completion of deferred tests.
 2. Schedule and coordinate deferred tests. Schedule deferred tests when specified conditions are available. Notify Architect and Commissioning Authority at least five working days (minimum) in advance of tests.
 3. Where deferred tests are specified, coordinate participation of necessary personnel and of Architect, Commissioning Authority, and Owner's witness. Schedule deferred tests to minimize occupant and facility impact. Obtain Architect's approval of the proposed schedule.
- J. Delayed Tests:
1. Delayed Test List: Identify, in the request for Certificate of Construction-Phase Commissioning Process Completion, proposed delayed tests. Obtain Owner approval of proposed delayed tests, including proposed schedule of completion of each delayed test, before submitting request for Certificate of Construction-Phase Commissioning Process Completion. Include the following in the request for Certificate of Construction-Phase Commissioning Process Completion:

- a. Identify delayed tests by test number and title.
 - b. Written approval of proposed delayed tests, including approved schedule of completion of delayed tests.
- 2. Schedule and coordinate delayed tests. Schedule delayed tests when conditions that caused the delay have been rectified. Notify Architect and Commissioning Authority at least five working days (minimum) in advance of tests.
- 3. Where delayed tests are approved, coordinate participation of necessary personnel and of Architect, Commissioning Authority, and Owner's witness. Schedule delayed tests to minimize occupant and facility impact. Obtain Architect's approval of the proposed schedule.

K. Commissioning Compliance Issues:

- 1. Test results that are not within the range of acceptable results are commissioning compliance issues.
- 2. Track and report commissioning compliance issues until resolution and retesting are successfully completed.
- 3. If a test demonstration fails, determine the cause of failure. Direct timely resolution of issue and then repeat the demonstration. If a test demonstration must be repeated due to failure caused by Contractor work or materials, reimburse Owner for billed costs for the participation in the repeated demonstration.
- 4. Test Results: If a test demonstration fails to meet the acceptance criteria, perform the following:
 - a. Complete a commissioning compliance issue report form promptly on discovery of test results that do not comply with acceptance criteria.
 - b. Submit commissioning compliance issue report form within 24 hours of the test.
 - c. Determine the cause of the failure.
 - d. Establish responsibility for corrective action if the failure is due to conditions found to be Contractor's responsibility.
- 5. Commissioning Compliance Issue Report: Provide a commissioning compliance issue report for each issue. Do not report multiple issues on the same commissioning compliance issue report.
 - a. Exception: If an entire class of devices is determined to exhibit the identical issue, they may be reported on a single commissioning compliance issue report. (For example, if all return-air damper actuators that are specified to fail to the open position are found to fail to the closed position, they may be reported on a single commissioning issue report. If a single commissioning issue report is used for multiple commissioning compliance issues, each device shall be identified in the report, and the total number of devices at issue shall be identified.
 - b. Complete and submit Part 1 of the commissioning compliance issue report immediately when the condition is observed.
 - c. Record the commissioning compliance issue report number and describe the deficient condition on the data form.
 - d. Resolve commissioning compliance issues promptly. Complete and submit Part 2 of the commissioning compliance issue report when issues are resolved.
- 6. Diagnose and correct failed test demonstrations as follows:

- a. Perform diagnostic tests and activities required to determine the fundamental cause of issues observed.
 - b. Record each step of the diagnostic procedure prior to performing the procedure. Update written procedure as changes become necessary.
 - c. Record the results of each step of the diagnostic procedure.
 - d. Record the conclusion of the diagnostic procedure on the fundamental cause of the issue.
 - e. Determine and record corrective measures.
 - f. Include diagnosis of fundamental cause of issues in commissioning compliance issue report.
7. Retest:
- a. Schedule and repeat the complete test procedure for each test demonstration for which acceptable results are not achieved. Obtain signature of Owner's witness on retest data forms. Repeat test demonstration until acceptable results are achieved. Except for issues that are determined to result from design errors or omissions, or other conditions beyond Contractor's responsibility, compensate Owner for direct costs incurred as the result of repeated test demonstrations to achieve acceptable results.
 - b. For each repeated test demonstration, submit a new test data form, marked "Retest."
8. Do not correct commissioning compliance issues during test demonstrations.
- a. Exceptions will be allowed if the cause of the issue is obvious and resolution can be completed in less than five minutes. If corrections are made under this exception, note the deficient conditions on the test data form and issue a commissioning compliance issue report. A new test data form, marked "Retest," shall be initiated after the resolution has been completed.

3.6 COMMISSIONING MEETINGS

- A. Commissioning Authority will schedule and conduct commissioning meetings. Comply with requirements in Section 013100 "Project Management and Coordination."

3.7 SEQUENCING

- A. Sequencing of Commissioning Verification Activities: For a particular material, item of equipment, assembly, or system, perform the following in the order listed unless otherwise indicated:
 - 1. Construction Checklists:
 - a. Material checks.
 - b. Installation checks.
 - c. Startup, as appropriate. Some startup may depend on component performance. Such startup may follow component performance tests on which the startup depends.

d. Performance Tests:

- 1) Static tests, as appropriate.
- 2) Component performance tests. Some component performance tests may depend on completion of startup. Such component performance tests may follow startup.
- 3) Equipment and assembly performance tests.
- 4) System performance tests.
- 5) Intersystem performance tests.

2. Commissioning tests.

- B. Before performing commissioning tests, verify that materials, equipment, assemblies, and systems are delivered, installed, started, and adjusted to perform according to construction checklists.
- C. Verify readiness of materials, equipment, assemblies, and systems by performing tests prior to performing test demonstrations. Notify Architect if acceptable results cannot be achieved due to conditions beyond Contractor's control or responsibility.
- D. Commence tests as soon as installation checks for materials, equipment, assemblies, or systems are satisfactorily completed. Tests of a particular system may proceed prior to completion of other systems, provided the incomplete work does not interfere with successful execution of test.

3.8 SCHEDULING

- A. Commence commissioning process as early in the construction period as possible.
- B. Commissioning Schedule: Integrate commissioning activities into Construction Schedule. See Section 013200 "Construction Progress Documentation."
 1. Include detailed commissioning activities in monthly updated Construction Schedule and short-interval schedule submittals.
 2. Schedule the start date and duration for the following commissioning activities:
 - a. Submittals.
 - b. Preliminary operation and maintenance manual submittals.
 - c. Installation checks.
 - d. Startup, where required.
 - e. Performance tests.
 - f. Performance test demonstrations.
 - g. Commissioning tests.
 - h. Commissioning test demonstrations.
 3. Schedule shall include a line item for each installation check, startup, and test activity specific to the equipment or systems involved.
 4. Determine milestones and prerequisites for commissioning process. Show commissioning milestones, prerequisites, and dependencies in monthly updated critical-path-method construction schedule and short-interval schedule submittals.

C. Two-Week Look-Ahead Commissioning Schedule:

1. Two weeks prior to the beginning of tests, submit a detailed two-week look-ahead schedule. Thereafter, submit updated two-week look-ahead schedules weekly for the duration of commissioning process.
2. Two-week look-ahead schedules shall identify the date, time, beginning location, Contractor personnel required, and anticipated duration for each startup or test activity.
3. Use two-week look-ahead schedules to notify and coordinate participation of Owner's witnesses.

D. Owner's Witness Coordination:

1. Coordinate Owner's witness participation via Architect.
2. Notify Architect of commissioning schedule changes at least three work days in advance for activities requiring the participation of Owner's witness.

3.9 COMMISSIONING REPORTS

A. Test Reports:

1. Pre-startup reports include observations of the conditions of installation, organized into the following sections:
 - a. Equipment Model Verification: Compare contract requirements, approved submittals, and provided equipment. Note inconsistencies.
 - b. Preinstallation Physical Condition Checks: Observe physical condition of equipment prior to installation. Note conditions including, but not limited to, physical damage, corrosion, water damage, or other contamination or dirt.
 - c. Preinstallation Component Verification Checks: Verify components supplied with the equipment, preinstalled or field installed, are correctly installed and functional. Verify external components required for proper operation of equipment correctly installed and functional. Note missing, improperly configured, improperly installed, or nonfunctional components.
 - d. Summary of Installation Compliance Issues and Corrective Actions: Identify installation compliance issues and the corrective actions for each. Verify that issues noted have been corrected.
 - e. Evaluation of System Readiness for Startup: For each item of equipment for each system for which startup is anticipated, document in summary form acceptable to Owner completion of equipment model verification, preinstallation physical condition checks, preinstallation component verification checks, and completion of corrective actions for installation compliance issues.
2. Test data reports include the following:
 - a. "As-tested" system configuration. Complete record of conditions under which the test was performed, including, but not limited to, the status of equipment, systems, and assemblies; temporary adjustments and settings; and ambient conditions.
 - b. Data and observations, including, but not limited to, data trend logs, recorded during the tests.
 - c. Signatures of individuals performing and witnessing tests.

- d. Data trend logs accumulated overnight from the previous day of testing.
3. Commissioning Compliance Issue Reports: Report as commissioning compliance issues results of tests and test demonstrations that do not comply with acceptance criteria. Report only one issue per commissioning compliance issue report. Use sequentially numbered facsimiles of commissioning compliance issue report form included in this Section, or other form approved by Owner. Distribute commissioning compliance issue reports to parties responsible for taking corrective action. Identify the following:
- a. Commissioning compliance issue report number. Assign unique, sequential numbers to individual commissioning compliance issue reports when they are created, to be used for tracking.
 - b. Action distribution list.
 - c. Report date.
 - d. Test number and description.
 - e. Equipment identification and location.
 - f. Briefly describe observations about the performance associated with failure to achieve acceptable results. Identify the cause of failure if apparent.
 - g. Diagnostic procedure or plan to determine the cause (include in initial submittal)
 - h. Diagnosis of fundamental cause of issues as specified below (include in resubmittal).
 - i. Fundamental cause of unacceptable performance as determined by diagnostic tests and activities.
 - j. When issues have been resolved, update and resubmit the commissioning issue report forms by completing Part 2. Identify resolution taken and the dates and initials of the persons making the entries.
 - k. Schedule for retesting.
4. Weekly progress reports include information for tests conducted since the preceding report and the following:
- a. Completed data forms.
 - b. Equipment or system tested, including test number, system or equipment tag number and location, and notation about the apparent acceptability of results.
 - c. Activities scheduled but not conducted per schedule.
 - d. Commissioning compliance issue report log.
 - e. Schedule changes for remaining Commissioning-Process Work, if any.
5. Data trend logs shall be initiated and running prior to the time scheduled for the test demonstration.
- a. Trend log data format shall be multiple data series graphs. Where multiple data series are trend logged concurrently, present the data on a common horizontal time axis. Individual data series may be presented on a segmented vertical axis to avoid interference of one data series with another, and to accommodate different axis scale values. Graphs shall be sufficiently clear to interpret data within the accuracy required by the acceptance criteria.
 - b. Attach to the data form printed trend log data collected during the test or test demonstration.

- c. Record, print out, and attach to the data form operator activity during the time the trend log is running. During the time the trend log is running, operator intervention not directed by the test procedure invalidates the test results.
- 6. System Alarm Logs: Record and print out a log of alarms that occurred since the last log was printed. Evaluate alarms to determine if the previous day's work resulted in any conditions that are not considered "normal operation."
 - a. Conditions that are not considered "normal operation" shall be reported on a commissioning issue report attached to the alarm log. Resolve as necessary. The intent of this requirement is to discover control system points or sequences left in manual or disabled conditions, equipment left disconnected, set points left with abnormal values, or similar conditions that may have resulted from failure to fully restore systems to normal, automatic control after test completion.

3.10 CERTIFICATE OF CONSTRUCTION-PHASE COMMISSIONING PROCESS COMPLETION

- A. When Contractor considers that construction-phase commissioning process, or a portion thereof which Owner agrees to accept separately, is complete, Contractor shall prepare and submit to Owner and Commissioning Authority through Architect a comprehensive list of items to be completed or corrected. Failure to include an item on such list does not alter Contractor's responsibility to complete commissioning process.
- B. On receipt of Contractor's list, Commissioning Authority will make an inspection to determine whether the construction-phase commissioning process or designated portion thereof is complete. If Commissioning Authority's inspection discloses items, whether included on Contractor's list, which is not sufficiently complete as defined in "Construction-Phase Commissioning Process Completion" Paragraph in the "Definitions" Article, Contractor shall, before issuance of the Certificate of Construction-Phase Commissioning Process Completion, complete or correct such items on notification by Commissioning Authority. In such case, Contractor shall then submit a request for another inspection by Commissioning Authority to determine construction-phase commissioning process completion.
- C. Contractor shall promptly correct deficient conditions and issues discovered during commissioning process. Costs of correcting such deficient conditions and issues, including additional testing and inspections, the cost of uncovering and replacement, and compensation for Architect's and Commissioning Authority's services and expenses made necessary thereby, shall be at Contractor's expense.
- D. When construction-phase commissioning process or designated portion is complete, Commissioning Authority will prepare a Certificate of Construction-Phase Commissioning Process Completion that shall establish the date of completion of construction-phase commissioning process. Certificate of Construction-Phase Commissioning Process Completion shall be submitted prior to requesting inspection for determining date of Substantial Completion.

END OF SECTION 019113

SECTION 019119.43 EXTERIOR ENCLOSURE COMMISSIONING

PART 1 - GENERAL

1.1 GENERAL DESCRIPTION

- A. ECS Mid-Atlantic, LLC, is an independent, third-party Building Enclosure Commissioning Provider retained by the Owner to perform Building Enclosure Commissioning.
- B. Building Enclosure Commissioning (BECx) is a quality-oriented process for verifying and documenting that the performance of building enclosure systems and assemblies meet defined objectives and criteria. The Commissioning process begins at project inception and continues through the life of the facility. The commissioning process includes specific tasks to be conducted during each phase to verify that design, construction, and training meets the owner's project requirements. Commissioning shall:
 - 1. Verify that applicable materials, components, and assemblies are installed according to the contract documents, manufacturer's recommendations, and industry-accepted minimum standards.
 - 2. Verify and document proper performance of applicable materials, components, and assemblies.
 - 3. The commissioning process is not intended to achieve LEED points for the project.
- C. The building enclosure commissioning team is made up of the Building Enclosure Commissioning Provider as well as representatives from the owner, architect, design engineers, general contractor, subcontractors of certain construction trades. The lead person for each trade who will perform and/or supervise the work shall be the designated representative for the building enclosure commissioning team. All team members work together to fulfill their contracted responsibilities and meet the objectives of the contract documents.
- D. The BECx Provider shall have the responsibility for coordinating each step of the building enclosure commissioning process in coordination with the Owner and the CxA. The contractors and trade representatives shall perform the tasks required in each step as described in this section.
- E. Work under this contract shall conform to Division 1 – General requirements.

1.2 ENCLOSURE SYSTEMS TO BE COMMISSIONED

- A. Building Enclosure
 - 1. Water Control Assemblies and Systems
 - 2. Air Control Assemblies and Systems
 - 3. Thermal Control Assemblies and Systems
 - 4. Vapor Control Assemblies and Systems

1.3 RELATED WORK AND DOCUMENTS

- A. 019113 – GENERAL COMMISSIONING REQUIREMENTS
- B. 042200 – UNIT MASONRY
- C. Division 07 – THERMAL AND MOISTURE PROTECTION
- D. Division 08 - OPENINGS

1.4 DEFINITIONS & ABBREVIATIONS

- A. Refer to section 01 91 13 (General Commissioning Requirements) of the Project Specifications for definitions and abbreviations not included below:
- B. Approval: Acceptance that a material or system has been properly installed and is functioning in tested modes according to the Contract Documents.
- C. Building Enclosure Commissioning Provider (BECxP): BECx Provider directs and coordinates day-to-day building enclosure commissioning activities in coordination with the Owner and the CxA.
- D. Commissioning Provider (CxA): Cx Authority directs and coordinates day-to-day MEP commissioning activities - excluding BECx activities.
- E. Commissioning Plan: Overall plan developed after bidding that provides structure, schedule, and coordination planning for commissioning process. A specific building enclosure section will be added into the project's commissioning plan.
- F. Simulated Condition: Condition created for testing component or system (e.g., applying pressure differential across the building enclosure concurrent with water spray to simulate a wind-driven rain).
- G. Specifications: Construction specifications of Contract Documents.
- H. Mock-up: The activities where systems or materials are initially constructed and tested. Mock-ups are to be free-standing or in situ and approved prior to the commencing full-scale construction.
- I. Water Penetration/Leakage: Under test conditions includes water:
 - 1. On any interior surface of the system or assembly;
 - 2. Trapped within a system or assembly without a positive drainage path to the exterior of the building; or
 - 3. In a location where damage may occur by the presence of moisture.

1.5 ROLES AND RESPONSIBILITIES

- A. The following describes the roles of the trade contractors in the commissioning process.

1. General Contractor (GC)

- a) Review Commissioning Plan and Functional Performance Test requirements.
- b) Attend commissioning kick-off meeting and other commissioning team meetings.
- c) Incorporate commissioning activities into the construction schedule.
- d) Coordinate scheduling of the Performance Testing with contractors and commissioning team.
- e) Periodically update commissioning activities in the construction schedule.
- f) Facilitate cooperation of Sub-contractors in commissioning work.
- g) Submit copies of initial and final A/E approved submittals for commissioned system equipment to BECx Provider for review.
- h) Review BECx Provider submittal comments.
- i) Verify building enclosure materials and assemblies are ready for functional testing.
- j) Submit maintenance logs of all interim maintenance or repair tasks performed by Sub-contractors.
- k) Insure resolution of non-compliance and deficiencies in construction or test results. Obtain written documentation of completion from the appropriate Sub-contractors.
- l) Provide letters of compatibility for adjacent building enclosure materials and assemblies.
- m) Provide all access, equipment, water, power, etc. required to complete Building Enclosure Functional Performance Testing.
- n) Facilitate all repairs and retesting of failed condition and pay for all associated costs.
- o) Provide all warranty information to BECx Provider.

2. Trade Contractors

- a) Review Commissioning Plan and Functional Performance Testing requirements.
- b) Attend commissioning kick-off meeting and other commissioning team meetings.
- c) Notify GC and BECx Provider of work completion.
- d) Attend all required material and systems testing.
- e) Execute all periodic maintenance or repairs required on started systems from initial mock-up of equipment to final acceptance by Owner to prevent material warranties from being voided.
- f) Ensure installation work is complete, is in compliance with Contract Documents, and is ready for Functional Performance Testing. Notify GC that equipment and systems are ready for Functional Performance Testing (FPT). FPT results will be observed and documented by BECx Provider.
- g) Provide all warranty information to GC.

B. The following paragraphs present a brief description of the responsibilities of parties outside of trade divisions. These descriptions are provided to assist the trade contractors in their understanding of the overall commissioning process

1. Owner(s)

- a) Provide Owner's Project Requirements (OPR) on which design is based.
- b) Identify and assign a representative who has the authority to make decisions in a timely manner regarding the commissioning process.
- c) Assists BECx Provider with the resolution of identified issues.
- d) Assign maintenance personnel to participate in the commissioning process.

2. Architect(s)

- a) Provide Design Intent and Basis of Design information that developed from the Owner's Requirements.
- b) Incorporate references and requirements into appropriate sections of the specifications which alert the contractor(s) of their commissioning responsibilities.
- c) Help to ensure the BECx Provider is part of the Building Enclosure submittal review process.
- d) Assists BECx Provider with the resolution of identified issues.
- e) Coordination of construction activities in support of BECx to allow for all verification and testing activities to be performed by the BECxP during regularly scheduled BECx Site Visits

3. Commissioning Authority

- a) Coordinates the activities and deliverables of the BECx Provider

4. Building Enclosure Commissioning Provider

- a) Participate in an initial team conference call (and/or meetings as may be contracted).
- b) Initial review of construction documents.
- c) Develop building enclosure portion of the Cx Plan.
- d) Write building enclosure commissioning specification section.
- e) Develop building enclosure functional performance test plan.
- f) Attend preconstruction meetings.
- g) Review RFI's, Trade Contractor checklists and product submittals pertinent to building enclosure performance.
- h) Review final shop drawings pertinent to building enclosure performance concurrent with A/E.
- i) Observe and document the construction of mockups.
- j) Observe and document functional performance testing on mockups.
- k) Make periodic site visits to document installations pertinent to building enclosure performance.
- l) Attend commissioning meetings periodically.
- m) Review, track, and coordinate resolution of non-compliance and deficiencies identified by commissioning team. Maintain a master issues list including the tracking of resolution.
- n) Observe and document building enclosure functional performance testing on building.
- o) Provide final building enclosure commissioning report.

5. Building Enclosure Testing Agency (BETA)

- a) To be hired by the contractor.
- b) Attend commissioning kick-off meeting and other commissioning team meetings.
- c) Provide on-site technician and equipment to complete mock-up and field Functional Performance Testing.
- d) Prepare and submit reports at the conclusion of all testing.
- e) Perform retesting and prepare corresponding reports.

1.6 QUALITY ASSURANCE

- A. Appropriate personnel (i.e. Project Manager and/or Field Foreman) employed by the General Contractor and certain Trades Contractors shall assist the BECx Provider in coordinating and executing the required commissioning activities. These personnel shall become familiar with the Commissioning Plan and shall coordinate the tasks, documentation and submissions required by this Plan. These personnel shall review these documents for compliance with the commissioning requirements and shall arrange for remedies to deficiencies noted in these documents.
- B. The owner has engaged an independent Building Enclosure Commissioning Provider (BECx Provider). The Contractor shall properly coordinate with the BECx Provider throughout the construction of the project.
- C. The BECx Provider will be an objective advocate of the owner observing the commissioning activities of the Contractor and will make final recommendations to the owner regarding functional performance of the commissioned building systems. The BECx Provider will prepare a Commissioning Plan for coordination with the design/build team to assure an efficient design and construction process.
- D. All approved submittal data for building enclosure systems and components to be commissioned shall be submitted to the BECx Provider for use in the BECx process. The Contractor shall submit additional copies of submittals, as requested, for the use in the Building Enclosure Commissioning process.
- E. The Contractor shall schedule the work considering the activities to be performed by the Building Enclosure Commissioning Provider. No claim for delay or request for an extension of Contract Time will be allowed as the result of the scheduled activities of the Building Enclosure Commissioning Provider.

1.7 DOCUMENTATION

- A. Owner's Project Requirements (OPR): A written document, prepared by the owner, outlining the owner's expectations and goals for the performance of the building upon project completion.
- B. Basis of Design (BOD): A written document, prepared by the Architect and design team, outlining the primary thought processes and assumptions behind the design decisions that were made to meet the Owner's Project Requirements. The Basis of Design describes the systems, components, conditions, and methods chosen to meet these requirements.
- C. Commissioning Plan: An overall plan, prepared by the Cx Provider and BECx Provider, which provides the structure, schedule and coordination planning for the commissioning process.
- D. Field Observations: The BECx Provider shall record observations, and measurements on performed tests. Photographs, forms, and other means appropriate for the application shall be included. BECx Provider shall compile site reports and include them in systems manual and commissioning report.
- E. Issues Log: BECx Provider shall prepare and maintain an issues log that describes design, installation, and performance issues that are in variance with the OPR, BOD, and Contract

Documents. BECx Provider shall document corrective action taken for systems and equipment that fail tests including the required modifications to systems and equipment and revisions to test procedures, as applicable.

- F. Final Commissioning Report: BECx Provider shall document results of the commissioning process including unresolved issues and performance of systems and assemblies. The commissioning report shall indicate whether systems are performing in accordance with the OPR, BOD, and Contract Documents. The commissioning report will be updated and re-submitted after the 10-month warranty site observation.
- G. The GC shall provide copies of documents gathered or developed during the construction process to the Building Enclosure Commissioning Provider in a timely and accurate manner. The documents required are:
 - 1. Construction schedule, including estimated dates for system installations and testing. Provide updated schedules as appropriate.
 - 2. Procedures and status reports, including deficiencies noted.
 - 3. Minutes from all meetings concerning building enclosure contractors and/or the building enclosure commissioning process.
 - 4. Field checklists used by the field technicians.
 - 5. As-built records, including approved submittals, warranties, and operations manuals.

PART 2 - PRODUCTS

2.1 TOOLS AND EQUIPMENT

- A. The appropriate Trades Contractor shall furnish all special tools and equipment required during the commissioning process. The owner shall furnish necessary utilities for the commissioning process.

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

- A. Trade Contractors to prepare detailed Construction Checklists for building enclosure systems, assemblies, and components; submit Construction Checklists for review.
- B. Return construction checklists incorporating BECx Provider comments.
- C. When review comments have been resolved, BECx Provider will provide final Construction Checklists, marked "Approved for Use, (date)."
- D. Use only Construction Checklists, marked "Approved for Use, (date)."

3.2 BUILDING ENCLOSURE COMMISSIONING (BECx) MEETINGS

- A. BECx meetings will be held periodically as determined by BECx Provider.

- B. Discussions held in BECx meetings shall include, but not be limited to, system/materials, mock-up/field, progress, scheduling, testing, documentation, deficiencies, and problem resolution.

3.3 REPORTING

- A. BECx Provider will provide status reports to GC, A/E and Owner as needed and/or after each site visit.
- B. BECx Provider shall submit non-compliance and deficiency reports to GC, A/E and Owner as needed and/or update after each site visit.
- C. BECx Provider shall provide a final summary report to the Owner at the completion of the project.

3.4 MOCK-UP AND FINAL CONSTRUCTION

- A. General Contractor and Sub-contractors shall verify completion of all assemblies compliant with project documents and deficiency log items prior to functional performance testing or concealment of functional performance layers within the building enclosure.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. Objectives and Scope

- 1. The objective of Functional Performance Testing is to demonstrate each system is operating according to documented design intent and Contract Documents. Functional Performance Testing facilitates bringing systems from a state of substantial completion to fully operational. Additionally, during Functional Performance Testing, areas of deficient performance are identified and corrected, improving operation and functioning of systems.

B. Development of Test Procedures

- 1. The purpose of any given specific test is to verify and document compliance with the Contract Documents. The BECx Provider shall develop specific test procedures for inclusion.

C. Coordination and Scheduling

- 1. GC will provide sufficient notice to BECx Provider regarding completion schedule for materials and systems. GC will schedule Functional Performance Tests with BETA. BECx Provider shall witness and document functional testing of materials and assemblies. BETA shall execute tests under direction of BECx Provider. BETA may be the same entity as the BECx Provider if deemed the best value to the project.
- 2. Successful completion of mock-up functional performance testing shall occur prior to full production installation of building enclosure materials and systems

D. Laboratory Mockup Testing

- 1. A project-specific laboratory mockup testing is not required for this project beyond those required in the contract documents to prove manufacturer typical system and assembly conformance.

E. Onsite Off-Building Mockup Testing

1. BETA: Contractor to engage a qualified testing agency to perform tests and inspections.
2. Exterior Mockup Testing Program: Perform the following tests in the following order:
 - a) Smoke Testing: ASTM E1186 at a static-air-pressure differential of 1.57 lbf/sq. ft.
 - b) Static Fenestration Testing: Conduct one test prior to the installation of exterior insulation or cladding:
 1. Storefront Air Infiltration: 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. at a static-air-pressure differential of 1.57 lbf/sq. ft.
 2. Storefront Water Penetration under Static Pressure: ASTM E1105 at a minimum uniform and cyclic static-air-pressure differential of 0.67 times the static-air-pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft., and shall not evidence water penetration.
 - c) Pull-off Strength of Adhered Air Barriers: ASTM D4541 as modified by ABAA. Minimum 16 lbf/sq. in. adhesion to substrate.
 - d) Failure: Should failure occur repair the area and retest.

F. Building Enclosure Testing

1. BETA: Contractor to engage a qualified testing agency to perform tests and inspections.
2. Building Enclosure Testing: Perform testing before installation of interior finishes unless otherwise indicated.
3. Testing Locations: To be selected by BECx Provider, Owner, and Architect.
4. Testing Agency: BETA to complete the following testing.
 - a) See Section 072702.3.4.B for ABAA testing and inspection requirements for the closed-cell spray polyurethane foam.
 - b) Roof: Perform high or low-voltage electronic leak detection per ASTM E7877 and an infrared scan per ASTM C1153.
 - c) See Section 079200.3.3.B.1 for sealant joint testing requirements.
 - d) Nozzle Testing: AAMA 501.2; No evidence of water penetration. Conduct one test at 30%, 60%, and 90% completion of the fenestration systems prior to the installation.
 1. Static Fenestration Testing: Each test area to include the full rough opening width and height. Conduct one test at 30%, 60%, and 90% completion of the fenestration systems prior to the installation of the cladding and interior finishes:
 - a) Storefront Air Infiltration: 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. at a static-air-pressure differential of 1.57 lbf/sq. ft.
 - b) Storefront Water Penetration under Static Pressure: ASTM E1105 at a minimum uniform and cyclic static-air-pressure differential of 0.67 times the static-air-

pressure differential specified for laboratory testing in "Performance Requirements" Article, but not less than 6.24 lbf/sq. ft., and shall not evidence water penetration.

- c) Failure: Should a failure occur contractor to make repairs, retest, and test one additional similar location.
- 2. Opaque Wall Air Leakage Testing: ASTM E1186 Bubble Gun testing. Failure Criteria: Bubbling of detection liquid under 75 PA.
- 3. Whole Building Air Barrier Testing
 - a) Whole Building Air Leakage Rate by Fan Pressurization: ASTM E799. Maximum Air Leakage Rate: 0.25 cfm/sf.
 - b) Test to be considered as an additional alternate for owner's consideration.

3.6 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Documentation

- 1. BECx Provider will witness and document results of Functional Performance Testing. This does not remove requirements for the BETA to provide a report on the testing.

B. Non-Conformance

- 1. BECx Provider will record results of functional testing. Deficiency or non-conformance issues will be noted and reported to GC, A/E and Owner.
- 2. Corrections of minor deficiencies identified may be made during tests at discretion of BECx Provider. In such cases, deficiency and resolution will be documented.
- 3. Every effort will be made to expedite testing and minimize unnecessary delays, while not compromising integrity of tests. BECx Provider shall not overlook deficient work or loosen acceptance criteria to satisfy scheduling or cost issues unless directed to do so by the Owner.
- 4. Deficiencies are handled in the following manner:
 - a) When there is no dispute on deficiency and Sub-contractor accepts responsibility for remedial action:
 - 1. BECx Provider documents deficiency and Sub-contractors response and intentions and they go on to another test or installation. BECx Provider submits deficiency report to GC, A/E and Owner. Copy is provided to Sub-contractor by GC. Sub-contractor corrects deficiency and certifies that material or assembly is ready to be retested. GC informs CT of retesting schedule.
 - 2. GC reschedules test with BECx Provider.
 - b) When there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
 - 1. BECx Provider documents deficiency and Contractor's response. BECx Provider submits deficiency report to GC, A/E and Owner. Copy is provided to Sub-contractor by GC.

2. GC facilitates resolution of deficiency. Other parties are brought into discussions as needed. Final interpretive authority is with A/E. Final acceptance authority is with the Owner.
 3. GC documents resolution process.
- c) Once interpretation and resolution has been decided, appropriate party corrects deficiency, GC reschedules test, and test is repeated until satisfactory performance is achieved.

C. Cost of Retesting

1. Costs for all retesting will be the full responsibility of the GC and Sub-contractors. These costs include all access, equipment, labor, redeployment of test crews, and materials required to complete the retesting.

3.7 COMMISSIONING DOCUMENTATION

A. Final Report Details

1. Final commissioning report will include an executive summary, list of participants and roles, brief building description, overview of commissioning and testing scope, and general description of testing and verification methods. Report will contain evaluation regarding.
 - a) Conformance to specifications and design intent
 - b) Material/system installation
 - c) Functional performance
2. All outstanding non-compliance items will be specifically listed.
3. Recommendations for improvement to system or operations, future actions, etc. will also be listed.

END OF SECTION 019119.43

SECTION 09 30 13 - CERAMIC TILING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Quarry tile.
 - 2. Porcelain tile.
 - 3. Glazed wall tile.

1.2 ACTION SUBMITTALS

- A. Product Data: For each type of product.
- B. Sustainable Design Submittals:
 - 1. Each type and composition of tile and for each color and finish required.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.

1.4 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match and are from same production runs as products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Tile and Trim Units: Furnish quantity of full-size units equal to 3 percent of amount installed for each type, composition, color, pattern, and size indicated.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications:
 - 1. Installer is a Five-Star member of the National Tile Contractors Association or a Trowel of Excellence member of the Tile Contractors' Association of America.
 - 2. Installer's supervisor for Project holds the International Masonry Institute's Foreman Certification.

PART 2 - PRODUCTS

2.1 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide Standard-grade tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.
- B. ANSI Standards for Tile Installation Materials: Provide materials complying with ANSI A108.02, ANSI standards referenced in other Part 2 articles, ANSI standards referenced by TCNA installation methods specified in tile installation schedules, and other requirements specified.

2.2 TILE PRODUCTS

- A. Square-Edged Quarry Tile Type: Unglazed.
 - 1. Daltile Quarry Tile, QT-1 (or approved equal)
 - 2. Face Size: 6 by 6 inches
 - 3. Thickness: 1/2 inch
 - 4. Wearing Surface: Abrasive
 - 5. Dynamic Coefficient of Friction: Not less than 0.42.
 - 6. Finish: Mat, opaque
 - 7. Tile Color and Pattern: OQ42Arid Gray
 - 8. Grout Color: As indicated by manufacturer's designations.
 - 9. Trim Units: Coordinated with sizes and coursing of adjoining flat tile where applicable and matching characteristics of adjoining flat tile. Provide shapes as follows, selected from manufacturer's standard shapes:
 - a. Base, B-3: Coved with round bottom and all required coordinating corner pieces, face size 5 by 6 inches (127 by 152 mm)
- B. Porcelain Tile Type:
 - 1. Daltile Reminiscent (or approved equal)
 - 2. Certification: Tile certified by the Porcelain Tile Certification Agency.
 - 3. Face Size: 12 by 24 inches
 - 4. Face Size Variation: Rectified.
 - 5. Thickness: 5/16" (7.8 mm)
 - 6. Face: Plain with square or cushion edges
 - 7. Dynamic Coefficient of Friction: Not less than 0.42.
 - 8. Tile Color, Glaze, and Pattern: Aged Beige RM21 (CT-1), 33% Offset
 - 9. Grout Color: Bostik Mobe Pearl H145
- C. Glazed Wall Tile Type:
 - 1. Daltile Color Wheel Classic (or approved equal)
 - 2. Module Size: 6 by 6 inches (152 by 152 mm)
 - 3. Face Size Variation: Rectified.
 - 4. Thickness: 5/16 inch (8 mm).

5. Face: Pattern of design indicated on drawings, with manufacturer's standard edges
6. Finish: Mat, opaque
7. Tile Color and Pattern: Urban Putty 0761 (CT-3), Artisan Brown 0744 (CT-4)
8. Grout Color: Bostik Mobe Pearl H145
9. Trim Units
 - a. At GWB partitions: Coordinated with sizes and coursing of adjoining flat tile where applicable. Provide shapes as follows, selected from manufacturer's standard shapes
 - 1) Base (CT-2): Bullnose with rounded top and all required coordinating corner pieces, face size 6 by 6 inches
 - b. At Tiled Partitions: Schluter trim as indicated on drawings.
- D. Internal Corners: Schluter trim as indicated on drawings.

2.3 SETTING MATERIALS

- A. Portland Cement Mortar (Thickset) Installation Materials: ANSI A108.02.
- B. Standard Dry-Set Mortar (Thinset): ANSI A118.1.
 1. For wall applications, provide nonsagging mortar.
- C. Modified Dry-Set Mortar (Thinset): ANSI A118.4.
 1. Provide prepackaged, dry-mortar mix to which only water must be added at Project site.
 2. Provide prepackaged, dry-mortar mix combined with liquid-latex additive at Project site.
 3. For wall applications, provide nonsagging mortar.
- D. Improved Modified Dry-Set Mortar (Thinset): ANSI A118.15.
 1. Provide prepackaged, dry-mortar mix to which only water must be added at Project site.
 2. Provide prepackaged, dry-mortar mix combined with liquid-latex additive at Project site.
 3. For wall applications, provide nonsagging mortar.
- E. Water-Cleanable, Tile-Setting Epoxy: ANSI A118.3.
- F. Organic Adhesive: ANSI A136.1, Type I.

2.4 GROUT MATERIALS

- A. Sand-Portland Cement Grout: ANSI A108.10, consisting of white or gray cement and white or colored aggregate as required to produce color indicated.
- B. Standard Cement Grout: ANSI A118.6.
- C. High-Performance Tile Grout: ANSI A118.7.
 1. Polymer Type:
 - a. Dry, redispersible form, prepackaged with other dry ingredients.
 - b. Liquid-latex form for addition to prepackaged dry-grout mix.
- D. Water-Cleanable Epoxy Grout: ANSI A118.3, with a VOC content of 65 g/L or less.

2.5 MISCELLANEOUS MATERIALS

- A. Trowelable Underlayments and Patching Compounds: Latex-modified, portland cement-based formulation provided or approved by manufacturer of tile-setting materials for installations indicated.
- B. Transitions: Schluter transitions as indicated on drawings.
- C. Floor Sealer: Manufacturer's standard product for sealing grout joints and that does not change color or appearance of grout.
- D. Cementitious Backer Units:
 - 1. Basis of Design : USG Durock Brand Cement Board with Edgeguard item 170215 (or Approved equal)
 - a. Thickness: 1/4"
 - b. Width: 3 ft
 - c. Length: 5ft
 - d. Recycled Content: 14%

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions where tile will be installed, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - 1. Verify that substrates for setting tile are firm; dry; clean; free of coatings that are incompatible with tile-setting materials, including curing compounds and other substances that contain soap, wax, oil, or silicone; and comply with flatness tolerances required by ANSI A108.01 for installations indicated.
 - 2. Verify that concrete substrates for tile floors installed with adhesives, bonded mortar bed or thinset mortar comply with surface finish requirements in ANSI A108.01 for installations indicated.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Fill cracks, holes, and depressions in concrete substrates for tile floors installed with adhesives or thinset mortar with trowelable leveling and patching compound specifically recommended by tile-setting material manufacturer.
- B. Where indicated, prepare substrates to receive waterproof membrane by applying a reinforced mortar bed that complies with ANSI A108.1A and is sloped 1/4 inch per foot (1:50) toward drains.
- C. Blending: For tile exhibiting color variations, verify that tile has been factory blended and packaged so tile units taken from one package show same range of colors as those taken from

CERAMIC TILING

other packages and match approved Samples. If not factory blended, either return to manufacturer or blend tiles at Project site before installing.

3.3 INSTALLATION

- A. Comply with TCNA's "Handbook for Ceramic, Glass, and Stone Tile Installation" for TCNA installation methods specified in tile installation schedules. Comply with parts of the ANSI A108 series "Specifications for Installation of Ceramic Tile" that are referenced in TCNA installation methods, specified in tile installation schedules, and apply to types of setting and grouting materials used.
 - 1. For the following installations, follow procedures in the ANSI A108 series of tile installation standards for providing 95 percent mortar coverage:
 - a. Tile floors in wet areas.
 - b. Tile floors consisting of tiles 8 by 8 inches or larger.
- B. Extend tile work into recesses and under or behind equipment and fixtures to form complete covering without interruptions unless otherwise indicated. Terminate work neatly at obstructions, edges, and corners without disrupting pattern or joint alignments.
- C. Accurately form intersections and returns. Perform cutting and drilling of tile without marring visible surfaces. Carefully grind cut edges of tile abutting trim, finish, or built-in items for straight aligned joints. Fit tile closely to electrical outlets, piping, fixtures, and other penetrations so plates, collars, or covers overlap tile.
- D. Provide manufacturer's standard trim shapes where necessary to eliminate exposed tile edges.
- E. Where accent tile differs in thickness from field tile, vary setting bed thickness so that tiles are flush.
- F. Jointing Pattern: Lay tile in grid pattern unless otherwise indicated. Lay out tile work and center tile fields in both directions in each space or on each wall area. Lay out tile work to minimize the use of pieces that are less than half of a tile. Provide uniform joint widths unless otherwise indicated.
- G. Joint Widths: Unless otherwise indicated, install tile with the following joint widths:
 - 1. Quarry Tile: 1/4 inch
 - 2. Glazed Wall Tile: 1/16 inch
 - 3. Porcelain Tile: 1/4 inch
- H. Expansion Joints: Provide expansion joints and other sealant-filled joints, including control, contraction, and isolation joints, where indicated. Form joints during installation of setting materials, mortar beds, and tile. Do not saw-cut joints after installing tiles.
 - 1. Where joints occur in concrete substrates, locate joints in tile surfaces directly above them.
- I. Metal Edge Strips: Install at locations indicated. Install at all internal corners.

- J. Install tile backing panels and treat joints according to ANSI A108.11 and manufacturer's written instructions for type of application indicated.
- K. Install waterproof membrane to comply with ANSI A108.13 and manufacturer's written instructions to produce waterproof membrane of uniform thickness that is bonded securely to substrate.
- L. Install crack isolation membrane to comply with ANSI A108.17 and manufacturer's written instructions to produce membrane of uniform thickness that is bonded securely to substrate.
- M. **Install cementitious backer units at all CMU partitions receiving ceramic tile.**

3.4 INTERIOR CERAMIC TILE INSTALLATION SCHEDULE

A. Interior Floor Installations, Concrete Subfloor:

1. ~~TCNA F112 and ANSI A108.1A: Cement mortar bed (thickset) bonded to concrete.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Bond Coat for Cured Bed Method: Standard dry-set mortar.~~
 - c. ~~Grout: Sand portland cement grout.~~
2. ~~TCNA F113: Thinset mortar.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Thinset Mortar: Standard dry-set mortar.~~
 - c. ~~Grout: Sand portland cement grout.~~
3. TCNA F115 : Thinset mortar; epoxy grout.
 - a. Ceramic Tile Type: As indicated on Drawings.
 - b. Thinset Mortar: Standard dry-set mortar.
 - c. Grout: Water-cleanable epoxy grout.
4. ~~TCNA F116 : Organic adhesive.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Grout: Sand portland cement grout.~~
5. ~~TCNA F131 : Water cleanable, tile setting epoxy; epoxy grout.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Grout: Water cleanable epoxy grout.~~
6. ~~TCNA F132 : Water cleanable, tile setting epoxy on cured cement mortar bed bonded to concrete subfloor; epoxy grout.~~
 - a. ~~Ceramic Tile Type: As indicated on drawings.~~
 - b. ~~Grout: Water cleanable epoxy grout.~~

~~B. Interior Wall Installations, Masonry or Concrete:~~

1. ~~TCNA W202: Thinset mortar.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Thinset Mortar: Standard dry set mortar.~~
 - c. ~~Grout: Sand portland cement grout.~~
2. ~~TCNA W211 and ANSI A108.1A: Cement mortar bed (thickset) bonded to substrate.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - d. ~~Grout: Sand portland cement Water cleanable epoxy grout.~~
 - e. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - f. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - g. ~~Grout: Sand portland cement grout.~~
 - h. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - i. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - j. ~~Grout: Sand portland cement grout.~~
3. ~~TCNA W223 : Organic adhesive.~~
 - a. ~~Ceramic Tile Type: As Indicated on the Drawings.~~
 - b. ~~Grout: Sand portland cement grout.~~

C. Interior Wall Installations, Wood or Metal Studs or Furring:

1. ~~TCNA W221 and ANSI A108.1A: Cement mortar bed (thickset) on solid backing.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings~~
 - b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - d. ~~Grout: Sand portland cement grout.~~
2. ~~TCNA W222 and ANSI A108.1A: One coat cement mortar bed (thickset) on solid backing.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - d. ~~Grout: Sand portland cement grout.~~
3. ~~TCNA W223: Organic adhesive on solid backing.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Grout: Sand portland cement grout.~~
4. ~~TCNA W231/W241 and ANSI A108.1A: Cement mortar bed (thickset).~~
 - a. ~~Ceramic Tile Type: As indicated on drawings.~~
 - b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~

- d. ~~Grout: Sand portland cement grout.~~
- 5. ~~TCNA W242: Organic adhesive on gypsum board.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Grout: Sand portland cement grout.~~
- 6. TCNA W243 : Thinset mortar on gypsum board.
 - a. Ceramic Tile Type: As indicated on Drawings.
 - b. Thinset Mortar: Standard dry-set mortar.
 - c. Grout: ~~Sand portland cement~~ Water cleanable epoxy grout.
- 7. TCNA W245 or TCNA W248: Thinset mortar on glass-mat, water-resistant gypsum backer board.
 - a. Ceramic Tile Type: As indicated on Drawings.
 - b. Thinset Mortar: Standard dry-set mortar.
 - c. Grout: ~~Sand portland cement~~ Water cleanable epoxy grout.

D. Cementitious backer units at CMU wall Installations:

- 1. **TCNA B419: Thinset mortar on ¼” cementitious backer units.**
 - a. **Secure Cementitious backer units to CMU: ¼” Type 1 organic adhesive.**
 - b. **Ceramic Tile Type: As indicated on the Drawings.**
 - c. **Thinset Mortar: Modified dry-set mortar.**
 - d. **Grout: Water cleanable epoxy grout.**

E. Shower Wall Installations, Wood or Metal Studs or Furring:

- 1. ~~TCNA B411 and ANSI A108.1A: Cement mortar bed (thickset) over vapor retarder membrane.~~
 - a. ~~Ceramic Tile Type: As indicated on Drawings.~~
 - b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
 - c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
 - d. ~~Grout: Sand portland cement grout.~~
- 2. TCNA B419: Thinset mortar on coated glass-mat, water-resistant gypsum backer board.
 - a. Ceramic Tile Type: As indicated on the Drawings.
 - b. Thinset Mortar: Modified dry-set mortar.
 - c. Grout: ~~Sand portland cement~~ Water cleanable epoxy grout.

F. Shower Receptor and Wall Installations:

- 1. ~~TCNA B414 and ANSI A108.1A: Cement mortar bed (thickset) over vapor retarder membrane.~~
 - a. ~~Ceramic Tile Type: As indicated on the Drawings.~~

- b. ~~Bond Coat for Wet Set Method: Standard dry set mortar.~~
- c. ~~Bond Coat for Cured Bed Method: Standard dry set mortar.~~
- d. ~~Grout: Sand portland cement grout.~~

2. TCNA B415: Thinset mortar.

- a. Ceramic Tile Type: As indicated on Drawings.
- b. Thinset Mortar: Standard dry-set mortar.
- c. Grout: ~~Sand portland cement~~ Water cleanable epoxy grout.

END OF SECTION 09 30 13

SECTION 09 67 23 - RESINOUS FLOORING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This section includes the following:
 - 1. Resinous flooring system as shown on the drawings and in schedules.
- B. Related sections include the following:
 - 1. Cast-in-Place Concrete, section 03 30 00

1.3 SYSTEM DESCRIPTION

- A. The work shall consist of preparation of the substrate, the furnishing and application of a pigmented epoxy based floor coating system with urethane topcoat. The system shall have the color and texture as indicated on drawings with a nominal thickness of 23 mils. It shall be applied to the prepared area(s) as defined in the plans strictly in accordance with the Manufacturer's recommendations.

1.4 SUBMITTALS

- A. Product Data: Latest edition of Manufacturer's literature including performance data and installation procedures.
- B. Manufacturer's Safety Data Sheet (SDS) for each product being used.
- C. Samples: A 3 x 3 inch square sample of the proposed system. Color, texture, and thickness shall be representative of overall appearance of finished system subject to normal tolerances.

1.5 QUALITY ASSURANCE

- A. The Manufacturer shall have a minimum of 10 years experience in the production, sales, and technical support of epoxy and urethane industrial flooring and related materials.
- B. The Applicator shall have experience in installation of the flooring system as confirmed by the manufacturer in all phases of surface preparation and application of the product specified.
- C. System shall be in compliance with requirements of United States Department of Agriculture (USDA), Food, Drug Administration (FDA), and local Health Department.
- D. A pre-installation conference shall be held between Applicator, General Contractor and the Architect to review and clarification of this specification, application procedure, quality control, inspection and acceptance criteria and production schedule.

1.6 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping

1. All components of the system shall be delivered to the site in the Manufacturer's packaging, clearly identified with the product type and batch number.

B. Storage and Protection

1. The Applicator shall be provided with a storage area for all components. The area shall be between 60 F and 90 F, dry, out of direct sunlight and in accordance with the Manufacturer's recommendations and relevant health and safety regulations.
2. Copies of Safety Data Sheets (SDS) for all components shall be kept on site for review by the Engineer or other personnel.

C. Waste Disposal

1. The Applicator shall be provided with adequate disposal facilities for non-hazardous waste generated during installation of the system.

1.7 PROJECT CONDITIONS

A. Site Requirements

1. Application may proceed while air, material and substrate temperatures are between 60 F and 90 F providing the substrate temperature is above the dew point. Outside of this range, the Manufacturer shall be consulted.
2. The relative humidity in the specific location of the application shall be less than 85 % and the surface temperature shall be at least 5 F above the dew point.
3. The Applicator shall ensure that adequate ventilation is available for the work area.
4. The Applicator shall be supplied with adequate lighting equal to the final lighting level during the preparation and installation of the system.

B. Conditions of new concrete to be coated with epoxy material.

1. Concrete shall be moisture cured for a minimum of 7 days and have fully cured a minimum of twenty-eight days in accordance with ACI-308 prior to the application of the coating system pending moisture tests.
2. Concrete shall have a flat rubbed finish, float or light steel trowel finish (a hard steel trowel finish is neither necessary nor desirable).
3. Sealers and curing agents should not be used.
4. Concrete surfaces on grade shall have been constructed with a vapor barrier to protect against the effects of vapor transmission and possible delamination of the system.

C. Safety Requirements

1. All open flames and spark-producing equipment shall be removed from the work area prior to commencement of application.
2. "No Smoking" signs shall be posted at the entrances to the work area.
3. Non-related personnel in the work area shall be kept to a minimum.

1.8 WARRANTY

- A. Warranty that material shipped to buyers at the time of shipment substantially free from material defects and will perform substantially to published literature if used in accordance with the latest prescribed procedures and prior to the expiration date.

PART 2 – PRODUCTS

2.1 FLOORING

- A. Dur-A-Flex, Inc, Dur-A-Gard, Epoxy-Based seamless flooring system (or approved equal)
1. System Materials:
 - a. Primer: Dur-A-Flex, Inc, Dur-A-Glaze #4 WB resin and hardener. (or approved equal)
 - b. Base Coat: Dur-A-Flex, Inc, Dur-A-Gard resin and hardener. (or approved equal)
 - c. Topcoat: Dur-A-Flex, Inc. Armor Top resin, hardener and pigment. (or approved equal)
 2. Patch Materials
 - a. Shallow Fill and Patching: Use Dur-A-Flex, Inc. Dur-A-Glaze #4 Cove Rez. (or approved equal)
 - b. Deep Fill and Sloping Material (over ¼ inch): Use Dur-A-Flex, Inc. Dur-A-Crete. (or approved equal)

2.2 MANUFACTURER

- A. Dur-A-Flex, Inc., (or approved equal)
- B. Manufacturer of Approved System shall be single source and made in the USA.

2.3 PRODUCT REQUIREMENTS

- | | |
|--|---------------------------------------|
| A. Primer | Dur-A-Glaze #4 WB (or approved equal) |
| 1. Percent Solids | 56 % |
| 2. VOC | 2 g/L |
| 3. Bond Strength to Concrete ASTM D 4541 | 550 psi, substrates fails |
| 4. Hardness, ASTM D 3363 | 3H |
| 5. Elongation, ASTM D 2370 | 9 % |
| 6. Flexibility (1/4: Cylindrical mandrel), ASTM D 1737 | Pass |
| 7. Impact Resistance, MIL D-2794 | >160 |
| 6. Abrasion Resistance ASTM D 4060,
CS 17 wheel, 1,000 g Load | 30 mg loss |
| B. Base Coat | Dur-A-Gard (or approved equal) |
| 1. Percent Solids | 100 % |
| 2. VOC | 3.45 g/L |
| 3. Compressive Strength, ASTM D 695 | 16,000 psi |
| 4. Tensile Strength, ASTM D 638 | 3,800 psi |
| 5. Flexural Strength, ASTM D 790 | 4,000 psi |
| 6. Abrasion Resistance, ASTM D 4060
C-10 Wheel, 1,000 gm load, 1,000 cycles | 35 mg loss |
| 7. Flame Spread/NFPA-101, ASTM E 84 | Class A |
| 8. Flammability, ASTM D 635 | Self Extinguishing |
| 9. Impact Resistance MIL D-3134 | 0.025 inch Max |

- | | |
|----------------------------------|---------------|
| 10. Water Absorption. MIL D-3134 | 0.04 % |
| 11. Potlife @ 70 F | 20-25 minutes |

C. Topcoat

Armor Top (or approved equal)

- | | |
|---|--------------------------------------|
| 1. Percent Solids | 95 % |
| 2. VOC | 0 g/L |
| 3. Tensile Strength, ASTM D 2370 | 7,000 psi |
| 4. Adhesion, ASTM 4541 | Substrate Failure |
| 5. Hardness, ASTM D 3363 | 4H |
| 6. 60° Gloss ASTM D 523 | 70 |
| 7. Abrasion Resistance, ASTM D4060 | Gloss Satin |
| CS 17 wheel (1,000 g load) 1,000 cycles | 4 8 mg loss with grit |
| | 10 12 mg loss without grit |
| 8. Pot Life, 70 F, 50% RH | 2 Hours |
| 9. Full Chemical Resistance | 7 days |

PART 3 – EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas and conditions, with Applicator present, for compliance with requirements for maximum moisture content, installation tolerances and other conditions affecting flooring performance.
1. Verify that substrates and conditions are satisfactory for flooring installation and comply with requirements specified.

3.2 PREPARATION

A. General

1. New and existing concrete surfaces shall be free of oil, grease, curing compounds, loose particles, moss, algae growth, laitance, friable matter, dirt, and bituminous products.
2. Moisture Testing: Perform tests recommended by manufacturer and as follows.
 - a. Perform relative humidity test using in situ probes, ASTM F 2170. Proceed with installation only after substrates have a maximum 75% relative humidity level measurement.
 - b. If the relative humidity exceeds 75% then a Primer moisture mitigation system must be installed prior to resinous flooring installation. Slab-on grade substrates without a vapor barrier may also require the moisture mitigation system.
3. There shall be no visible moisture present on the surface at the time of application of the system. Compressed oil-free air and/or a light passing of a propane torch may be used to dry the substrate.
4. Mechanical surface preparation
 - a. Shot blast all surfaces to receive flooring system with a mobile steel shot, dust recycling machine (Blastrac or equal). All surface and embedded accumulations of paint, toppings hardened concrete layers, laitance, power trowel finishes and other similar surface characteristics shall be completely removed leaving a bare concrete surface having a minimum profile of CSP 2-3 as described by the International Concrete Repair Institute.
 - b. Floor areas inaccessible to the mobile blast machines shall be mechanically abraded to the same degree of cleanliness, soundness and profile using diamond grinders, needle guns, bush hammers, or other suitable equipment.

- c. Cracks and joints (non-moving) greater than 1/8 inch wide are to be chiseled or chipped-out and repaired per manufacturer's recommendations.
5. At spalled or worn areas, mechanically remove loose or delaminated concrete to a sound concrete and patch per manufacturer's recommendations.

3.3 APPLICATION

A. General

1. The system shall be applied in four distinct steps as listed below:
 - a. Substrate preparation
 - b. Priming
 - c. Base coat application.
 - d. Topcoat application
2. Immediately prior to the application of any component of the system, the surface shall be dry and any remaining dust or loose particles shall be removed using a vacuum or clean, dry, oil-free compressed air.
3. The handling, mixing and addition of components shall be performed in a safe manner to achieve the desired results in accordance with the Manufacturer's recommendations.
4. The system shall follow the contour of the substrate unless pitching or other leveling work has been specified by the Architect.
5. A neat finish with well-defined boundaries and straight edges shall be provided by the Applicator.

B. Primer

1. The primer shall be mixed at the ratio of 1 part resin to 4 parts hardener per the manufacturer's instructions.
2. The primer shall be applied by 1/8 inch notched squeegee and back rolled at the rate of 200-250 sf/gal to yield a dry film thickness of 4 mils.

C. Base Coat

1. The base coat shall be comprised of two components, a resin, and hardener as supplied by the Manufacturer.
2. The resin shall be added to the hardener and thoroughly mixed by suitably approved mechanical means.
3. The base coat shall be applied over horizontal surfaces using "v" notched squeegee and back rolled at the rate of 100 sf/gal to yield a dry film thickness of 16 mils.

D. Topcoat

1. The topcoat shall be roller applied at the rate of 500 sf/gal to yield a dry film thickness of 3 mils.
2. The topcoat shall be comprised of a liquid resin, hardener and pigment that is mixed per the manufacturer's instructions.
3. The finish floor will have a nominal thickness of 23 mils.

3.4 FIELD QUALITY CONTROL

A. Tests, Inspection

1. The following tests shall be conducted by the Applicator:
 - a. Temperature
 1. Air, substrate temperatures and, if applicable, dew point.

b. Coverage Rates

1. Rates for all layers shall be monitored by checking quantity of material used against the area covered.

3.5 CLEANING AND PROTECTION

- A. Cure flooring material in compliance with manufacturer's directions, taking care to prevent their contamination during stages of application and prior to completion of the curing process.
- B. Remove masking. Perform detail cleaning at floor termination, to leave cleanable surface for subsequent work of other sections.

END SECTION 09 67 23

SECTION 220800 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section includes Cx process requirements for the following plumbing systems, assemblies, and equipment:
 - 1. Domestic hot- and cold-water piping.
 - 2. Sanitary waste and vent piping.
 - 3. Plumbing pumps.
 - 4. Plumbing equipment.
 - 5. Grease interceptor
- B. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 22 Sections specifying plumbing systems, system components, equipment, and products.

1.2 DEFINITIONS

- A. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- B. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- C. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they shall mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For plumbing testing technician.
- B. Construction Checklists:
 - 1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Contractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
- C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Contractor, provide the following:

1. Equipment/instrument identification number.
2. Planned Cx application or use.
3. Manufacturer, make, model, and serial number.
4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.4 QUALITY ASSURANCE

- A. Plumbing Testing Technician Qualifications: Technicians to perform plumbing Construction Checklist verification tests. Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 1. Journey level or equivalent skill level with knowledge of plumbing system, electrical concepts, and building operations.
 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. Testing Equipment and Instrumentation Quality and Calibration:
 1. Capable of testing and measuring performance within the specified acceptance criteria.
 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- C. Proprietary Test Instrumentation and Tools:
 1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Plumbing system proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 Cx PROCESS

- A. Perform Cx process for plumbing systems in accordance with:
 - 1. ASHRAE 202.

3.2 CONSTRUCTION CHECKLISTS

- A. Preliminary detailed construction checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each plumbing system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in ASHRAE 202. Contractor performs the following:
 - 1. Review plumbing preliminary construction checklists and provide written comments on Construction Checklist items where appropriate.
 - 2. Return preliminary Construction Checklist with review comments within 14 days of receipt.
 - 3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
 - 4. Use only construction checklists marked "Approved for Use, (date)." Mark construction checklists in the appropriate place, as indicated Project events are completed, and provide pertinent details and other information.
- B. Systems Required to Be Commissioned:
 - 1. Domestic hot-water systems and controls.
 - 2. Water-pumping and -mixing systems.
- C. Additional Systems Required to Be Commissioned:
 - 1. Domestic water piping, including the following:
 - a. Domestic cold- and hot-water piping, fittings, and specialties inside the building.
 - b. Pumps, motors, accessories, and controls.
 - c. Indoor water-storage tanks.
 - d. General-duty and specialty valves.
 - 2. Sanitary waste and vent piping, including the following:
 - a. Gravity sewerage piping, fittings, and specialties.
 - b. Sanitary waste interceptors.
 - c. Pumps, motors, accessories, and controls.
 - d. Drains.
 - e. Meters and gauges.
 - f. General-duty and specialty valves.

3. Plumbing fixtures, including the following:
 - a. Water closets, supports and connections, supplies, and flush valves.
 - b. Urinals, supports and connections, supplies, and flush valves.
 - c. Lavatories, supports, supplies, drain connections, and faucets.
 - d. Sinks, supports, supplies, drain connections, and faucets.
 - e. Showers, supplies, drain connections, and faucets.
 - f. Drinking fountains, supplies, and drainage connections.
4. Natural gas piping, in accordance with section 23 08 00, including the following:
 - a. Regulators
 - b. Meters
 - c. Gas piping, fittings, and specialties

3.3 Cx TESTING PREPARATION

- A. Certify that plumbing systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- B. Certify that plumbing system instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and that all systems are set to and maintaining set points as required by the design documents.
- C. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.4 Cx TEST CONDITIONS

- A. Perform tests using design conditions, whenever possible.
 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- B. If tests cannot be completed because of a deficiency outside the scope of the plumbing system, document the deficiency and report it to Architect. After deficiencies are resolved, reschedule tests.

- C. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.

3.5 Cx TESTS COMMON TO PLUMBING SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.
- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response compared to acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 22 Sections specifying plumbing systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

END OF SECTION 220800

SECTION 230800 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes Cx process requirements for the following HVAC systems, assemblies, and equipment:
 - 1. Energy supply systems.
 - 2. Heat generation systems.
 - 3. Cooling generation systems.
 - 4. Central-station air-handling systems.
 - 5. Air distribution systems.
 - 6. Heating and cooling terminal and unitary equipment.
 - 7. HVAC controls.
 - 8. TAB verification.
- B. Related Requirements:
 - 1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.
 - 2. For construction checklists, comply with requirements in various Division 23 Sections specifying HVAC systems, system components, equipment, and products.
 - 3. Section 220800 "Commissioning of Plumbing Systems."

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."
- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. TBCx: Total Building Commissioning
- E. IgCC: International Green Construction Code.
- F. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.

- G. TAB: Testing, adjusting, and balancing.

1.4 SEQUENCING AND SCHEDULING

- A. Complete the following prior to starting Functional Performance Tests of mechanical systems:
 - 1. All equipment and systems completed, cleaned, flushed, disinfected, calibrated, tested, and operate in accordance with contract documents and construction plans and specifications.
 - 2. Final DALT Report submitted and approved in accordance with Section 200000.
 - 3. The Certificate of Readiness submitted and approved in accordance with Section 019113.
 - 4. Pre-final Testing, Adjusting, and Balancing report submitted in accordance with Section 200000.
 - 5. Air Leakage Test Reports and Diagnostic Test Reports submitted in accordance with Section 07 05 23.
 - 6. Tests, Flushing, and Disinfection in accordance with Section 220000.

1.5 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For BAS and HVAC testing technician.
- B. Construction Checklists:
 - 1. Draft Cx plan, including draft construction checklists to be prepared by CxA under Section 019113 "General Commissioning Requirements." Div. 23 Subcontractor is to review Construction Checklist in accordance with requirements in Section 019113 "General Commissioning Requirements" and ASHRAE 202 and to resolve any issues with the CxA.
- C. Test Equipment and Instruments: For all test equipment and instruments to be used in conducting Cx tests by Div. 23 Subcontractor, provide the following:
 - 1. Equipment/instrument identification number.
 - 2. Planned Cx application or use.
 - 3. Manufacturer, make, model, and serial number.
 - 4. Calibration history, including certificates from agencies that calibrate the equipment and instrumentation.
 - 5. Equipment manufacturers' proprietary instrumentation and tools. For each instrument or tool, identify the following:
 - a. Instrument or tool identification number.
 - b. Equipment schedule designation of equipment for which the instrument or tool is required.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.

1.6 QUALITY ASSURANCE

- A. BAS Testing Technician Qualifications: Technicians performing BAS Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations are to have the following minimum qualifications:
 - 1. Journey level or equivalent skill level with knowledge of BAS, HVAC, electrical concepts, and building operations.
 - 2. Minimum three years' experience installing, servicing, and operating systems manufactured by approved manufacturer.
- B. HVAC Testing Technician Qualifications: Technicians to perform HVAC Construction Checklist verification tests, Construction Checklist verification test demonstrations, Cx tests, and Cx test demonstrations shall have the following minimum qualifications:
 - 1. Journey level or equivalent skill level; vocational school four-year-program graduate or an Associate's degree in mechanical systems, air conditioning, or similar field. Degree may be offset by three years' experience in servicing mechanical systems in the HVAC industry. Generally, required knowledge includes HVAC systems, electrical concepts, building operations, and application and use of tools and instrumentation to measure performance of HVAC equipment, assemblies, and systems.
 - 2. Minimum three years' experience that is to include installing, servicing, and operating systems manufactured by approved manufacturer.
- C. Testing Equipment and Instrumentation Quality and Calibration:
 - 1. Capable of testing and measuring performance within the specified acceptance criteria.
 - 2. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - 3. Be maintained in good repair and operating condition throughout duration of use on Project.
 - 4. Be recalibrated/repared if dropped or damaged in any way since last calibrated.
- D. Proprietary Test Instrumentation and Tools:
 - 1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, shall comply with the following:
 - a. Be calibrated by manufacturer with current calibration tags permanently affixed.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - 2. HVAC proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

- A. Provide all testing equipment required to perform testing for the systems to be commissioned, except for equipment specific to and used by TAB as required by Section 230000. Provide a sufficient quantity of two-way radios for each subcontractor. Submit list of Test Equipment and instrumentation to be used for testing including equipment/instrument identification number, equipment application or planned use, manufacturer, make, model, and serial number, and calibration history with certificates. Also list special equipment and proprietary tools specific to a piece of equipment required for testing.

PART 3 - EXECUTION

3.1 Cx PROCESS:

- A. Perform Cx process in accordance with Section 019113 "General Commissioning Requirements" for BAS and HVAC and in accordance with the following:
 - 1. IgCC, which requires compliance with ASHRAE 202.

3.2 MEETINGS

- A. Attend all meetings in accordance with Section 019113 "General Commissioning Requirements."
- B. Provide timely updates on construction schedule changes so Commissioning Provider has scheduling information needed to execute commissioning process efficiently. Notify Architect of anticipated construction delays to commissioning activities not yet performed or not yet scheduled.

3.3 PREFUNCTIONAL CHECKLISTS

- A. Complete and sign Pre-Functional Checklists using the Commissioning Provider's web-based commissioning software, or as specified by the commissioning plan. Provide manufacturer's installation manual for each type of unit. Perform all work in accordance with the manufacturer's published diagrams, recommendations, and equipment warranty requirements.
- B. Pre-Functional Checklists are to be prepared under Section 019113 "General Commissioning Requirements" for each BAS and HVAC system, assembly, subsystem, equipment, and component required to be commissioned, as detailed in IgCC and ASHRAE 202. Contractor performs the following:
 - 1. Review BAS and HVAC preliminary construction checklists and provide written comments on checklist items where appropriate.
 - 2. Return preliminary Construction Checklist with review comments within 14 days of receipt.

3. When review comments have been resolved, the CxA will provide final construction checklists marked "Approved for Use, (date)."
4. Use only construction checklists marked "Approved for Use, (date)" When performing tests. Mark construction checklists in the appropriate place as indicated Project events are completed, and provide pertinent details and other information.

C. Systems required to be commissioned:

1. Heating, ventilating, air-conditioning, and refrigeration systems (mechanical and/or passive) and associated controls.
2. Air-curtain systems.
3. Water-pumping and -mixing systems over 5 hp.
4. Energy and building management and demand-control systems.

D. Additional systems required to be commissioned:

1. Energy supply systems, including the following:
 - a. Fuel gas supply.
 - b. Demand-control systems.
2. Cooling generation systems, including the following:
 - a. Direct-expansion refrigeration systems.
3. Air-handling systems, including the following:
 - a. Supply, return, and exhaust air fans, motors, and drives.
 - b. Automatic and gravity dampers.
 - c. Heating and cooling devices.
 - d. Humidification and dehumidification devices.
 - e. Air filters.
 - f. Hangers and supports.
 - g. Interlock between air-handling system and fire/smoke alarm system.
4. Air duct systems, including the following:
 - a. Duct systems.
 - b. Air-duct accessories, including volume dampers, fire and smoke dampers, turning vanes, sound attenuators, and flexible connectors.
 - c. Duct-mounted access doors and panels.
 - d. Hangers and supports.
5. Air curtain systems.
 - a. Supply air fans and motors.
 - b. Heating and cooling devices.
6. Hydronic distribution systems, including the following:
 - a. Condensate piping systems, including condensate pumps and all accessories.

7. Refrigerant piping, including the following:
 - a. Refrigerant piping, fittings, and specialties.
 - b. Refrigerant charge.
 - c. Sleeves and sleeve seals.
 - d. Hangers and supports.
8. Smoke-control systems, including the following:
 - a. Smoke detectors.
9. Heating and cooling terminal and unitary equipment, including the following:
 - a. Unit heaters.
 - b. Fan-coil units.
 - c. Electric heating.
10. Controls and instrumentation, including the following:
 - a. Energy monitoring and recording system.
 - b. Controllers and sensors.
 - c. Automatic control valves, dampers, and actuators.
 - d. Control interface with fans, pumps, dampers, and other equipment and systems.
 - e. Demand-control systems.
11. TAB Verification:
 - a. Airflow.
 - b. Differential pressure controls
12. Documentation:
 - a. Mechanical systems manuals.
 - b. Documentation of required commissioning.
13. Mechanical insulation, including the following:
 - a. Duct and plenum insulation.
 - b. HVAC piping insulation.

3.4 Cx TESTING PREPARATION

- A. Document start-up and initial testing procedures including:
 1. Startup tests and factory testing reports
 2. Manufacturer's representative start-up, operating, troubleshooting, and maintenance procedures.
 3. Additional documentation necessary for third party certification programs.
 4. Perform and clearly document system operational checks and quality control checks as they are completed and providing a copy to the commissioning team.
 5. Correct deficiencies and sign the Certificate of Readiness for each system before functional performance testing.

- B. Certify that HVAC systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating in accordance with the Contract Documents and approved submittals.
- C. Certify that HVAC instrumentation and control systems have been completed and calibrated, point-to-point checkout has been successfully completed, and systems are operating in accordance with their design sequence of operation, Contract Documents, and approved submittals. Certify that all sensors are operating within specified accuracy and all systems are set to and maintaining set points as required by the design documents.
- D. Certify that TAB procedures have been completed and that TAB reports have been submitted, discrepancies corrected, and corrective work approved.
- E. Set systems, subsystems, and equipment into operating mode to be tested in accordance with approved test procedures (e.g., normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).

3.5 COMMISSIONING TESTING

- A. Conduct Functional Performance Testing in accordance with Section 019103, "General Building Commissioning Requirements," and requirements in this section. Prior to Functional Performance Testing, complete all prerequisites in accordance with paragraph SEQUENCING AND SCHEDULING.
- B. Preparation
 - 1. Put equipment and systems into operation and continue operation during each working day of commissioning, as required. Verify temperature and pressure taps in accordance with Contract Documents. Provide a pressure/temperature plug at each water sensor which is an input point to control system.
 - 2. Perform minor adjustments to equipment and systems during Functional Performance Tests as deemed necessary by the commissioning team. Where calibrated DDC sensors cannot be used to record test data, provide measuring instruments, logging devices, and data acquisition equipment to record data for the complete range of test data for the required test period.
- C. Test Setup
 - 1. Perform each test under conditions that simulate actual conditions as close as is practically possible. Provide all necessary materials and system modifications to produce the necessary flows, pressures, temperatures, and other conditions necessary to execute the test according to the specified conditions. At completion of the test, return the affected building equipment and systems to their pre-test condition.
- D. Manufacturer's Representative
 - 1. Provide a factory trained representative authorized by the equipment manufacturer to perform Functional Performance Testing for the following equipment:
 - a. Boilers
 - b. Packaged Direct-Expansion Refrigeration Equipment, including variable refrigerant flow (VRF) systems.
 - c. Water Quality and Chemical Treatment Systems

- d. Ensure the test representative reviews, approves, and signs the completed field test report. Include person's name with signatures.
 - e. Kitchen exhaust and makeup air systems
 - f. Kitchen hoods
- E. Sample Strategy
 - 1. Perform Functional Performance Tests using the sample strategy described in Section 019103. Prepare and complete a Functional Performance Test for each item of equipment or system to be tested. During testing, Government representatives may select the specific equipment or system to be tested for sample sizes less than 100 percent.
- F. Simulating Conditions
 - 1. Functional performance testing is conducted by simulating conditions at control devices to initiate a control system response. Before testing, calibrate all sensors, transducers and devices. Over-writing control input values through the control system is not acceptable unless approved by the Contracting Officer. Specific examples of simulating conditions are provided below. Do not simulate conditions when damage to the system or building may result.
 - a. When varying static pressures inside ductwork cannot be simulated within the duct, and where a sensor signals the controls system to initiate sequences at various duct static pressures, it is acceptable to simulate the various pressures with a Pneumatic Squeeze-Bulb Type Signaling Device with gauge temporarily attached to the sensing tube leading to the transmitter. It is not acceptable to reset the various set-points, nor to simulate an electric analog signal (unless approved as noted above).
 - b. Dirty filter pressure drops can be simulated by partially blocking filter face.
 - c. Freeze-stat safeties can be simulated by packing portion of sensor with ice.
 - d. High outside air temperatures can be simulated with a hair blower.
 - e. Raising entering cooling coil temperatures by activating a heating/preheat coil can be used to simulate entering cooling coil conditions.
 - f. Do not use signal generators to simulate sensor signals unless approved by the Contracting Officer, as noted above, for special cases.
 - g. Control set points can be altered. For example, to see the air conditioning compressor lockout work at an outside air temperature below 55 degrees F, when the outside air temperature is above 55 degrees F, temporarily change the lockout set point to be 0 degrees F above the current outside air temperature. Caution: Set points are not to be raised or lowered to a point to cause damage to the components, systems, or the building structure and/or contents.
 - h. Test duct mounted smoke detectors in accordance with the manufacturer's recommendations. Perform the tests with air system at minimum airflow condition.
 - i. Test current sensing relays used for fan and pump status signals to control system to indicate unit failure and run status by resetting the set point on the relay to simulate a lost belt or unit failure while the unit is running. Confirm that the failure alarm was generated and received at the control system. After the test is conducted, return the set point to its original set-point or a set-point as indicated by the Contracting Officer.
- G. Duct Air Leakage Test (DALT) Report Verification
 - 1. The Commissioning Specialist is responsible for witnessing the DALT Field Acceptance Testing specified by Section 230000 and identifying any deficiencies to the Contracting

Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to DALT Report approval.

- H. Testing, Adjusting, and Balancing (TAB) Report Verification
 - 1. The Commissioning Coordinator is responsible for witnessing the TAB Field Acceptance Testing specified by Section 230000 and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to TAB Report approval.
- I. HVAC Controls Test Procedures, Reports, and Trends Review
 - 1. The Commissioning Coordinator is responsible for reviewing the Start-Up Testing Report, PVT Procedures and PVT Reports including endurance testing trend data required by Section 230000 and identifying any deficiencies to the Contracting Officer's Representative and the Contractor's Quality Control Personnel. All deficiencies must be resolved prior to final acceptance.

3.6 RETESTING REQUIREMENTS

- A. Abort tests if any deficiency prevents successful completion of the test or if any required commissioning team member is not present for the test. Re-test only after all deficiencies identified during the original tests have been corrected.
- B. If sequence of operation in any of Functional Performance Tests fails, the Government's costs for witnessing further demonstration of that test procedure may be assigned to the Contractor as a deduct to their contracted price, including salary, travel costs, and per diem for Government commissioning team members. Correct deficiencies as identified by the commissioning team and retest the systems to be commissioned.

3.7 SEASONAL TESTS

- A. Perform Initial Functional Performance Tests as soon as all contract work is completed, but prior to facility turnover, regardless of the season.
- B. In addition to the Initial Functional Performance Tests, perform Functional Performance Tests of HVAC systems during season of maximum heating and cooling.
- C. Schedule Seasonal Functional Performance Tests in coordination with the Contracting Officer. Submit Seasonal Test Report within 14 days of test completion.
- D. Execute seasonal functional performance testing, witnessed by the Contracting Officer. Correct deficiencies and make adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

3.8 Cx TESTS COMMON TO HVAC SYSTEMS

- A. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions, to verify compliance with acceptance criteria.

- B. Test systems, assemblies, subsystems, equipment, and components for operating modes, interlocks, control responses, responses to abnormal or emergency conditions, and response in accordance with acceptance criteria.
- C. Coordinate schedule with, and perform Cx activities at the direction of, CxA.
- D. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance test requirements specified in Division 23 Sections specifying HVAC systems and equipment.
- E. Provide technicians, instrumentation, tools, and equipment to perform and document the following:
 - 1. Cx Construction Checklist verification tests.
 - 2. Cx Construction Checklist verification test demonstrations.

3.9 TAB VERIFICATION

- A. Prerequisites: Completion requirements and correction of deficiencies, as specified in Section 200000 "General Mechanical Requirements."
- B. Preparation of a TAB plan that includes strategies and step-by-step procedures, and system-readiness checks and reports, as specified in Section 200000 "General Mechanical Requirements."
- C. Scope: HVAC air systems.
- D. Purpose: Differential flow relationships intended to maintain air pressurization differentials between the various areas of Project.
- E. Conditions of the Test:
 - 1. Systems operating in full heating mode with minimum outside-air volume.
 - 2. Systems operating in full cooling mode with minimum outside-air volume.
 - 3. For measurements at air-handling units with economizer controls; systems operating in economizer mode with 100 percent outside air.
- F. Acceptance Criteria:
 - 1. Under all conditions, rechecked measurements comply shall not differ from measurements documented in the final report by more than the tolerances allowed.
 - 2. Under all conditions, where the Contract Documents indicate a differential in airflow between supply and exhaust and/or return in a space, the differential relationship shall be maintained.

3.10 TRAINING

- A. The Commissioning Provider is responsible for overseeing and approving the training plan required by Section 01 78 00 Operation and Maintenance Data and identifying any deficiencies to the Owner.

- B. Coordinate, schedule, and document all required training. At a minimum, include the following items in the training report for commissioned systems:
1. Complete commissioning documentation
 2. Complete O&M data
 3. Complete Training
 4. Purpose of equipment.
 5. Principle of how the equipment works.
 6. Important parts and assemblies.
 7. How the equipment achieves its purpose and necessary operating conditions.
 8. Most likely failure modes, causes and corrections.
 9. On site demonstration.
 10. Provide updates to O&M manuals based on field modifications.
 11. Provide training of the post-occupancy operations and maintenance staff.

SECTION 260800 - COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Electrical equipment connected to Normal electrical systems, including the following:
 - a. Transformers.
 - b. Secondary service electrical systems.
 - c. Distribution and branch-circuit panelboards.
 - d. Lightning protection systems.
 - e. Grounding systems.
 - f. Photovoltaic (PV) systems.
2. Electrical equipment connected to Emergency electrical systems that provide an alternative source of power in the absence of power from the Normal electrical system, including the following:
 - a. Lighting Control System
 - b. Lighting Inverter.
3. Controls and instrumentation, including the following:
 - a. Equipment monitoring systems.
 - b. Energy monitoring and control systems.
 - c. Electrical metering and metering system.
 - d. Demand response systems.
 - e. Lighting control systems.
 - f. Security systems.
 - g. Fire-alarm systems.
4. Systems testing and verification, including **Normal and Emergency** electrical systems

B. Related Requirements:

1. Section 019113 "General Commissioning Requirements" for general Cx process requirements and CxA responsibilities.

1.2 DEFINITIONS

- A. BoD: Basis-of-Design Document, as defined in Section 019113 "General Commissioning Requirements."
- B. Cx: Commissioning, as defined in Section 019113 "General Commissioning Requirements."

- C. CxA: Commissioning Authority, as defined in Section 019113 "General Commissioning Requirements."
- D. OPR: Owner's Project Requirements, as defined in Section 019113 "General Commissioning Requirements."
- E. "Systems," "Assemblies," "Subsystems," "Equipment," and "Components": Where these terms are used together or separately, they mean "as-built" systems, assemblies, subsystems, equipment, and components.

1.3 INFORMATIONAL SUBMITTALS

- A. Construction Checklists by CxA: Draft construction checklists will be created by CxA for Contractor review.
- B. Construction Checklists by Contractor: Include the following and comply with requirements in Section 019113 "General Commissioning Requirements" for construction checklists:
 - 1. Instrumentation and control for electrical systems.
 - 2. Instrumentation and control for lighting control systems.
 - 3. Low-voltage power cables.
 - 4. Control voltage power cables.
 - 5. Electrical feeders and branch circuits.
 - 6. Dry-type transformers.
 - 7. Switchgear and switchboard assemblies rated 1200 A or greater.
 - 8. Low-voltage surge protective devices.
 - 9. Protective relays.
 - 10. Metering devices.
 - 11. Molded-case circuit breakers.
 - 12. Low-voltage power circuit breakers.
 - 13. Disconnect/Safety switches.
 - 14. Grounding systems.
 - 15. Ground-fault protection systems.
 - 16. Panelboards.
 - 17. Receptacles and devices.
 - 18. Engine generators.
 - 19. Generator docking station.
 - 20. Automatic transfer switches.
 - 21. Battery systems.
 - 22. -
 - 23. Lighting.
 - 24. Vehicle charging equipment.

1.4 QUALITY ASSURANCE

- A. Testing Equipment and Instrumentation Quality and Calibration: For test equipment and instrumentation required to perform electrical Cx work, perform the following:

1. Submit test equipment and instrumentation list. For each equipment or instrument, identify the following:
 - a. Equipment/instrument identification number.
 - b. Planned Cx application or use.
 - c. Manufacturer, make, model, and serial number.
 - d. Calibration history, including certificates from agencies that calibrate equipment and instrumentation.
2. Test equipment and instrumentation must meet the following criteria:
 - a. Capable of testing and measuring performance within the specified acceptance criteria.
 - b. Be calibrated at manufacturer's recommended intervals with current calibration tags permanently affixed to the instrument being used.
 - c. Be maintained in good repair and operating condition throughout duration of use on Project.
 - d. Be recalibrated/repared if dropped or damaged in any way since last calibrated.

B. Proprietary Test Instrumentation and Tools:

1. Equipment Manufacturer's Proprietary Instrumentation and Tools: For installed equipment included in the Cx process, test instrumentation and tools manufactured or prescribed by equipment manufacturer to service, calibrate, adjust, repair, or otherwise work on its equipment or required as a condition of equipment warranty, perform the following:
 - a. Submit proprietary instrumentation and tools list. For each instrument or tool, identify the following:
 - 1) Instrument or tool identification number.
 - 2) Equipment schedule designation of equipment for which the instrument or tool is required.
 - 3) Manufacturer, make, model, and serial number.
 - 4) Calibration history, including certificates from agencies that calibrate the instrument or tool, where appropriate.
 - b. Include a separate list of proprietary test instrumentation and tools in operation and maintenance manuals.
 - c. Electrical proprietary test instrumentation and tools become property of Owner at the time of Substantial Completion.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 CONSTRUCTION CHECKLISTS

3.2 CONSTRUCTION CHECKLIST REVIEW

- A. Review and provide written comments on draft construction checklists. CxA will create required draft construction checklists and provide them to Contractor.
- B. Return draft Construction Checklist review comments within **10** days of receipt.
- C. When review comments have been resolved, CxA will provide final construction checklists, marked "Approved for Use, (date)."
- D. Use only construction checklists, marked "Approved for Use, (date)."

3.3 GENERAL TESTING REQUIREMENTS

- A. Certify that electrical systems, subsystems, and equipment have been installed, calibrated, and started and that they are operating according to the Contract Documents and approved Shop Drawings and submittals.
- B. Certify that electrical instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents and approved Shop Drawings and submittals, and that pretest set points have been recorded.
- C. Set systems, subsystems, and equipment into operating mode to be tested according to approved test procedures (for example, normal shutdown, normal auto position, normal manual position, unoccupied cycle, emergency power, and alarm conditions).
- D. Measure capacities and effectiveness of systems, assemblies, subsystems, equipment, and components, including operational and control functions to verify compliance with acceptance criteria.
- E. Test systems, assemblies, subsystems, equipment, and components operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and response according to acceptance criteria.
- F. Construction Checklists: Prepare and submit detailed construction checklists for electrical systems, subsystems, equipment, and components.
 - 1. Contributors to development of construction checklists must include, but are not limited to, the following:
 - a. Electrical systems and equipment installers.
 - b. Electrical instrumentation and controls installers.

- G. Perform tests using design conditions, whenever possible.
 - 1. Simulated conditions may, with approval of Architect, be imposed using an artificial load when it is impractical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by CxA, and document simulated conditions and methods of simulation. After tests, return configurations and settings to normal operating conditions.
 - 2. Cx test procedures may direct that set points be altered when simulating conditions is impractical.
 - 3. Cx test procedures may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are impractical.
- H. If tests cannot be completed because of a deficiency outside the scope of the electrical system, document the deficiency and report it to Owner. After deficiencies are resolved, reschedule tests.
- I. If seasonal testing is specified, complete appropriate initial performance tests and documentation and schedule seasonal tests.
- J. Coordinate schedule with, and perform Cx activities at the direction of the CxA.
- K. Comply with Construction Checklist requirements, including material verification, installation checks, startup, and performance tests requirements specified in Sections specifying electrical systems and equipment.
- L. Provide qualified testing and inspecting agency personnel in accordance with Section 260010 "Supplemental Requirements for Electrical," instrumentation, tools, and equipment to complete and document the following:
 - 1. Performance tests.
 - 2. Demonstration of a sample of performance tests.
 - 3. Cx tests.
 - 4. Cx test demonstrations.

3.4 Cx TESTS FOR ELECTRICAL SYSTEMS

- A. Verification of Normal Electrical System Operation:
 - 1. Prerequisites: Acceptance of results for construction checklists for Division 26 electrical components associated with Normal electrical system.
 - 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
 - 3. Test Purpose: Verify operation of Normal electrical system.
 - 4. Test Conditions: Energize components of Normal electrical system, one at a time.
 - 5. Acceptance Criteria: Proper operation of Normal electrical system over a **24**-hour period.
- B. Verification of Essential Electrical System Operation:
 - 1. Prerequisites:

- a. Acceptance of results for construction checklists for Division 26 electrical components associated with Essential electrical system.
 - b. Completion of "Verification of Normal Electrical System Operation" tests.
- 2. Equipment and Systems to Be Tested: Division 26 electrical equipment.
- 3. Test Purpose: Verify operation of Essential electrical system.
- 4. Test Conditions:
 - a. Energize components of Normal electrical system.
 - b. Simulate a failure of Normal electrical system.
- 5. Acceptance Criteria: Transfer of power from Normal to Essential electrical system within OPR.
- C. Test Purpose: Verify operation of control and monitoring systems for Normal and Essential electrical systems.
- D. Test Conditions:
 - 1. Energize components of Normal electrical system.
 - 2. Test operation of equipment.
- E. Acceptance Criteria: Operation of equipment according to OPR.

END OF SECTION 260800