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This Attachment sets forth Commissioning Agent's Scope of Work.

1.0 Overview of Facility

The following provides an overview of what the Facility includes:

- Tunnel:
  - A bored tunnel approximately 3.9 miles in length, with an approximate finished 21 feet inside diameter (I.D.) designed to accommodate a NPS 30 oil pipeline installed on pipe supports within the tunnel
  - Constructed under the Straits of Mackinac, within the plan limits shown on Attachment A-7 (Site and Right of Way), with a gasketed precast concrete segmental lining
- Pipeline:
  - Pipeline constructed north, south and through the bored tunnel
- Tunnel Systems:
  - Permanent tunnel utilities
  - Provisions for third-party utility installation (by others)
- Surface Facilities:
  - Above-ground or near-surface structures to house equipment required to support tunnel utilities
  - Power supply improvements to support tunnel construction from north and/or south portal
  - Connections to existing infrastructure on north and south shores
  - Site restoration and landscaping

2.0 Defined Terms: As defined in the Contractor's Scope of Work, and the Technical Specifications, and as follows:

2.1 Acceptance Phase: Phase of construction after startup and initial checkout when Functional Performance Tests, O&M documentation review and training occurs.

2.2 Acceptance: Agreement that a piece of equipment or system has been properly installed and is functioning according to the Agreement.

2.3 Building Automation System (BAS): The central building control and energy management system.

2.4 Commissioning Authority (CxA): An entity identified by the Company that leads, plans, schedules and coordinates the commissioning team to implement the Commissioning Process. The CxA reports directly to the Company without assuming oversight responsibilities.

2.5 Commissioning Plan (Cx Plan): A document that outlines the organization, schedule, allocation of resources and documentation requirements of the Commissioning Process.

2.6 Company-Contracted Tests: Tests paid for by the Company outside the Contract and for which the CxA does not oversee. These tests will not be repeated during functional tests if properly documented.

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2.7 Construction Agreement: The contract between the Company and the Contractor.

2.8 Data Logging: Monitoring flows, currents, status, pressures, etc. of equipment using stand-alone data loggers that are separate from the control system.

2.9 Deferred Functional Tests: Functional Tests that are performed after substantial completion. This is applicable when equipment, seasonal requirements, design or other site conditions disallow tests from being performed.

2.10 Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Agreement.

2.11 Design Basis Report: A document that records the concepts, systems, calculations, decisions, and product selections used to meet the Design Basis Report and to satisfy applicable regulatory requirements, Codes, Standards, and guidelines. The document includes both narrative descriptions and lists of individual items that support the design process.

2.12 Design Narrative or Design Documentation: Sections of the Design Basis Report.

2.13 Factory Testing: Testing of equipment on-site or at the factory, by factory personnel with District's representative present.

2.14 Functional Performance Test (FPT): Test of the dynamic function and operation of equipment and systems using simulations, manual (direct observation) and/or monitoring methods. Systems are tested under various modes. The systems are run through all the control system's sequences of operation and components are verified to be responding as intended per the specified sequence of operations. FPTs are performed after Pre-Functional Checklists and startup is complete.

2.15 Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100% closed.

2.16 Manual Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").

2.17 Monitoring: The recording of equipment operation parameters (flow, current, status, pressure, etc.) using data loggers or the trending capabilities of control systems.

2.18 Non-Compliance: see Deficiency.

2.19 Non-Conformance: see Deficiency.

2.20 Normal Submittals: Submittals required by the Construction Agreement and specified in various Technical Specifications in Divisions 22, 23, and 26.

2.21 Overwritten Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50 ºF to 75 ºF to verify economizer operation). See also "Simulated Signal".

2.22 Phased Commissioning: Commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.

2.23 Pre-Functional Checklist (PFC): A list of items to inspect and elementary component tests to conduct to verify proper installation of equipment. The Pre-Functional Checklists are developed by the CxA in conjunction with the Subs. Pre-Functional Checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil level check, labels affixed, gages in place, sensors calibrated, amp readings, etc.). Pre-Functional Checklists augment and are combined with the manufacturer's start-up checklist.

2.24 Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

2.25 Seasonal Performance Tests: Functional Performance Tests that are deferred until the system(s) experience conditions closer to their design conditions.

2.26 Simulated Condition: A condition that is artificially created for the purpose of testing the response of a system.

2.27 Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance, or pressure to the transducer and DDC system to simulate a sensor value.

2.28 Test Procedures: A written document developed by the CxA that details the expectations for tests conducted on components, equipment, assemblies, systems and interfaces among systems.

2.29 Test Requirements: Requirements specified in the Construction Agreement describing and indicating what modes and functions, etc. shall be tested.

2.30 Trending: Monitoring using the Building Automation System.

2.31 Vendor: Supplier of equipment.

3.0 General

3.1 This Attachment A-1 sets forth Construction Agreement Scope of Work, which comprises directing and coordinating the commissioning activities as Commissioning Agent and reporting directly to the Company for commissioning of the Plumbing, Mechanical, Electrical, and BAS (Building Automation System).

3.2 Description of Commissioning Process:

3.2.1 Commissioning is a quality focused process that enhances the delivery of a project. The process focuses on verifying and documenting that the facility and all of its Systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the Design Basis Report.

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3.2.2 The Commissioning process begins in the Pre-Design phase by developing and documenting the Design Basis Report and continues through construction, acceptance, and warranty periods to verify and document the performance of Systems.

3.2.3 A Commissioning Plan will be provided by the Commissioning Agent early in the Construction Phase to outline the commissioning process, including the roles and responsibilities of the project Commissioning Team. The plan shall identify the logistics, schedules and management protocols associated with the commissioning process. The plan shall be updated by the Commissioning Agent as required to accommodate project logistical changes. Commissioning during the Construction Phase is intended to achieve the following specific objectives in accordance with the Technical Specifications:

3.2.3.1 Verify that applicable equipment and Systems are installed in accordance with the manufacturer's instructions, industry accepted Standards and Technical Specifications. The Commissioning process verifies that all Equipment will receive adequate operational checkout by installing contractors.

3.2.3.2 Verify and document proper performance of Equipment and Systems.

3.2.3.3 Verify that Operation and Maintenance (O&M) documentation is available, accurate and complete.

3.2.3.4 Ensure that the Company's operating personnel are adequately trained to operate and maintain the Systems and Equipment.

3.2.4 The commissioning process does not take away from or reduce the responsibility of the Designer as System Designers or the Contractor to provide a finished and a fully functioning "as intended" product.

3.3 Commissioning Team:

3.3.1 The members of the commissioning team consist of the following:

3.3.1.1 The Company
3.3.1.2 The Commissioning Authority (CxA)
3.3.1.3 The Designer
3.3.1.4 The Contractor, including the Contractor's Subcontractor's as follows:

3.3.1.4.1. The Mechanical Contractor (MC)
3.3.1.4.2. The Electrical Contractor (EC)
3.3.1.4.3. The TAB Contractor (TAB)
3.3.1.4.4. The BAS Contractor (CC)
3.3.1.4.5. The Plumbing Contractor (PC)
3.3.1.4.6. The Controls Contractor (CC)
3.3.1.4.7. Other Subcontractors (Subs)
3.3.1.4.8. Vendors and Manufacturers (where applicable)

3.3.2 The members of the commissioning team work together to fulfill their contractual responsibilities and meet the objectives set forth in this scope of work.

3.4 The Commissioning Plan:

3.4.1 The Commissioning Plan provides guidance in the execution of the commissioning process.

3.4.2 The CxA shall prepare a draft Commissioning Plan which shall be binding on the Contractor.

3.4.3 Following the initial commissioning scoping meeting the CxA will update the plan which is then considered the "Final" plan, though it will continue to evolve and expand as the project progresses.

3.4.4 Should conflict arise between the specifications and the Commissioning Plan, the Company shall be notified and shall render a decision.

3.5 Commissioning Process: The following narrative provides a brief overview of the typical Commissioning tasks during construction and the general order in which they occur:

3.5.1 The CxA develops a comprehensive and project specific Commissioning Plan which provides the preliminary structure, Primevera Schedule and coordination for the Commissioning Process.

3.5.2 The CxA facilitates a Commissioning kickoff meeting where the Commissioning process is reviewed with the Commissioning team members. All Commissioning team members shall be present as the process, roles, responsibilities and Commissioning related questions will be addressed.

3.5.3 Additional meetings scheduled by the CxA with assistance from the CM will be required throughout construction. All necessary parties identified by the CxA must attend those meetings as they will be used to plan, coordinate and schedule future activities and resolve problems.

3.5.4 Equipment documentation shall be submitted to the CxA during the normal submittal processes. Documentation shall include, but not limited to: design drawings and submittals for equipment to be commissioned, in accordance with the requirements of the Construction Agreement. These will be reviewed by the CxA concurrently with the Designer's reviews.

3.5.5 The CxA works with the Contractor in developing startup plans and startup documentation formats, including providing the Contractor with Pre-Functional Checklists to be completed during the startup process.

3.5.6 The checkout and performance verification proceeds from simple to complex and from component level to equipment to system and

intersystem levels with Pre-Functional Checklists being completed before start of Functional Performance Testing.

3.5.7 The Contractor, under their own direction, shall execute and document the completion of initial system checkouts, system start-ups, and Pre-Functional Checklists. The CxA documents that the checklists and startup were completed according to the accepted plans. The CxA may witness start-up of selected equipment where determined to be necessary.

3.5.8 The CxA shall develop specific Equipment and System Functional Performance Test (FPT) procedures. The procedures shall be submitted to the Contractor and his Subcontractors for review to ensure test steps are feasible, safe and equipment protection is provided with necessary written alarm limits to be used during the test. FPT's are executed by the contractor(s), under the oversight and documentation of the CxA.

3.5.9 The Contractor and his Subcontractors shall correct Items of non-compliance in material, installation, or setup shall retest the systems as needed. All non-compliance items and any corrective actions taken shall be documented. All non-compliance items shall be corrected before the execution of Functional Performance Testing.

3.5.10 The CxA shall review the O&M documentation for completeness and compliance with the contract documents.

3.5.11 The CxA reviews and pre-approves the training plan provided by the Contractor and verifies that all required training was completed. The Contractor coordinates the scheduling of all trainings.

3.5.12 Deferred testing shall be conducted, as specified or required by the Contractor.

3.5.13 Commissioning shall be successfully completed before Substantial completion and turnover of the project.

3.5.14 The CxA issues a Commissioning Report to the Company.

3.5.15 The CxA works with Company and Contractor to assist in the resolution of any issues during the Contractor's Warranty Period

3.5.16 2-months prior to expiration of the Contractor's Warranty Period the CxA shall meet with the Company and facility maintenance personnel to review the facility operating procedures and determine if any warranty related issues shall be resolved by the Contractor.

4.0 Project Description

4.1 See Contractor's Scope of Work for Project Description.

5.0 References

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5.1 ASHRAE Standard 202, Commissioning process for Building and Systems.

5.2 ASHRAE Guideline 0, The Commissioning Process.

5.3 ASHRAE Guideline 1.1, HVAC Commissioning Guidelines.

5.4 ASHRAE Guideline 1.4, Procedures for Preparing FSM.

5.5 LEEDTM, New Construction Reference Guide.

5.6 NFPA 4: Standard for Integrated Fire Protection and Life Safety System Testing.

5.7 NFPA 3: Recommended Practice for Commissioning of Fire Protection and Life Safety Systems.

5.8 NFPA 110 Standard for Emergency and Standby Power Systems.

5.9 NFPA 111 Standard on Stored Electrical Energy Emergency and Standby Power Systems.

6.0 Scheduling:

6.1 The CxA shall work with the Company in accordance with the requirements of the Construction Agreement to schedule all the Commissioning activities.

6.2 The CxA shall provide sufficient notice to the Company and Contractor for scheduling Commissioning activities. The Contractor will integrate all Commissioning activities into the construction schedule.

6.3 The CxA shall work with Company and Contractor to address scheduling issues and make necessary notifications in a timely manner to expedite the Commissioning process.

7.0 Responsibilities of the CxA

7.1 The primary role of the CxA is to develop and coordinate the execution of a Commissioning Plan, observe and document performance and verify that systems are functioning in accordance with the Design Basis Report and in accordance with the Contractors Agreement.

7.2 The CxA is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management.

7.3 The CxA may assist with problem solving, non-conformance or deficiencies; however, the responsibility remains with the Designer and Contractor.

7.4 The CxA is not responsible for providing tools or the use of tools to start, checkout and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the CxA.

7.5 Construction and Acceptance Phase: CxA shall:

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7.5.1 CxA shall review Design Basis Report, specifications and selected design documents at various design phases, as required. This may include reviewing equipment and systems for installation, integration, testing, operations, maintenance, training, and warranty requirements.

7.5.2 Develop and issue a project-specific Commissioning Plan.

7.5.3 Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.

7.5.4 Coordinate the commissioning work with the Company and the Contractor and ensure that commissioning activities are being incorporated into the Contractor's Construction Schedule.

7.5.5 Plan and conduct the commissioning scoping meeting and follow-up commissioning coordination meetings as needed.

7.5.6 Attend selected planning and job-site meetings, as needed, to obtain information on construction progress. Review construction-meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.

7.5.7 Revise the Construction Phase Commissioning Plan and update as required.

7.5.8 Concurrent with the Designer, review Contractor submittals applicable to systems being commissioned for compliance with commissioning needs and Design Basis Report.

7.5.9 Request and review additional information and documentation required to perform commissioning tasks, including O&M materials, Contractor's vendor generated start-up and checkout procedures and manufacturer start-up and inspection reports.

7.5.10 Before startup, gather and review the current control sequences and interlocks and work with Contractor and Designer until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.

7.5.11 Prepare Pre-Functional Checklists.

7.5.12 Accept Pre-Functional Tests and checklist completed and submitted by the contractor by reviewing Pre-functional Checklist reports and by selected site observation or random spot-verification.

7.5.13 Prepare the Functional Performance Test procedures for equipment and systems. Submit to Company for review as an Action submittal.

7.5.14 Assist the commissioning team members responsible for start-up of any equipment in developing detailed start-up plans.

7.5.15 Perform site visits, as necessary, to observe component and system installations.

7.5.16 Accept systems startup by reviewing manufacturer's start-up reports and by selected site observation.

7.5.17 Review and comment on TAB execution plan and oversee sufficient Functional Testing and verification of the BAS (control system) and accept it for use by the TAB contractor, prior to commencing TAB work.

7.5.18 Verify air and water systems Testing and Balancing (TAB) by spot testing, reviewing completed reports and selected site observation.

7.5.19 Analyze any Functional Performance trend logs and monitoring data to verify the proper performance of systems and equipment.

7.5.20 Coordinate witness and accept Functional Performance Tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved.

7.5.21 Maintain a master deficiency and resolution log and a separate testing record. Provide the Company with written progress reports and test results with recommended actions.

7.5.22 Review equipment warranties to ensure they meet the specification requirements and that the Company's responsibilities to maintain the warranty are clearly defined.

7.5.23 Oversee and accept the training of the Company's operating personnel by Contractor in accordance with Construction Agreement. This includes preparing training agendas for commissioned equipment and systems.

7.5.24 Review and accept the preparation of the O&M manuals for all commissioned equipment and systems.

7.5.25 Provide a final Commissioning Report as described in this section.

7.5.26 Develop a systems manual per ASHRAE, "The Commissioning Process".

7.5.27 Prepare a standard trend logging package to provide the operating staff with clear description of system functions in order to identify proper system operation and troubleshooting problems. The CxA shall also provide any needed information on interpreting the trends.

7.6 Warranty Period: CxA shall:

7.6.1 Coordinate and supervise required seasonal or deferred testing and deficiency corrections.

7.6.2 Return to the site 10 months after substantial completion and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning.

7.6.3 Interview facility staff and identify problems or concerns they have operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals.

7.6.4 Identify areas of deficiency that may come under warranty or under the original construction contract. Assist facility staff in developing reports, documents and requests for Contractor services to remedy outstanding problems.

7.6.5 Assist in the development of a preventative maintenance plan, detailed operating plan or an energy and resource management plan or as-built documentation.

7.7 The CxA shall submit a commissioning milestone schedule which includes all commissioning related activities; these activities shall be integrated into the master construction schedule maintained by the Contractor.

7.8 The CxA may witness test activities specified in the Technical Specifications including select construction tests (e.g. piping pressure tests, duct leakage test, etc.) and equipment start-up tests.

7.9 Meetings:

7.9.1 Scoping Meeting:

7.9.1.1 Once the Commission Plan is prepared, and within 30 days of commencement of Tunnel Systems construction, the CxA shall schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. The CxA shall distribute meeting minutes to all parties.

7.9.1.2 The CxA shall update the Commissioning Plan within 30 days based on the information gathered from the meetings. The updated plan shall be accessible to all participating parties in the Commissioning process.

7.9.2 Miscellaneous Meetings:

7.9.2.1 Other meetings shall be planned and conducted by the CxA as construction progresses. These meetings shall cover coordination, deficiency resolution and planning issues with the Contractor. The CxA shall plan these meetings and will minimize unnecessary time being spent by Subcontractors. These meetings may be held monthly, until the final 3 months of construction where they may be held as frequently as once per week.

7.10 Reporting

7.10.1 The CxA shall provide regular reports to the Company, with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the Commissioning Plan.

7.10.2 The CxA shall regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports and the like.

7.10.3 The CxA shall provide testing or review acceptance, non-conformance and deficiency reports to the Company.

7.10.4 The CxA shall provide a final summary report to the Company, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. Acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., shall be compiled in appendices and provided with the summary report. Pre-functional checklists, functional performance tests and monitoring reports shall not be part of the final report, but shall be included in the Commissioning Record and in the O&M manuals.

7.11 Design Basis Review

7.11.1 The CxA shall conduct, at a minimum, one commissioning review of the Company's Design Basis Report for design agreement, clarity and completeness.

7.12 Design Document Review

7.12.1 The CxA shall conduct, at a minimum, one commissioning design review of the construction documents. CxA shall focus on identifying areas of concern with the design regarding coordination between divisions, constructability, maintenance clearances, operability or other commissioning concerns.

7.12.2 Design comments and responses generated as part of this review shall be documented and tracked by CxA in a comment review form. Comments not responded to prior to final design submission will be added to the Issues Log and are expected to be resolved during the project.

7.13 Submittals

7.13.1 The CxA shall provide the Contractor and appropriate Subcontractors with a specific request for the type of submittal documentation required to facilitate the commissioning work. These requests shall be integrated into the normal submittal process and protocol of the construction team. At minimum, the request shall include:

7.13.1.1 Equipment manufacturer and model number.
7.13.1.2 Selection and operating data (Example: Flow, pressure, fan curves, etc.).

7.13.1.3 The manufacturer's printed installation and detailed start-up procedures.

7.13.1.4 Full sequences of operation and control drawings.

7.13.1.5 O&M data, performance data, performance test procedures, details and results of Company-contracted tests.

7.13.1.6 Installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians.

7.13.2 The CxA shall review and accept submittals related to the commissioned equipment for conformance to the contract documents as it relates to the commissioning process, to the Functional Performance of the equipment and adequacy for developing test procedures.

7.13.3 The CxA's review is intended primarily to aid in the development of Functional Testing Procedures and only secondarily to verify compliance with equipment specifications. The CxA shall notify the Company and the Designer of items missing or areas that are not in conformance with contract documents and which require resubmission.

7.13.4 The CxA may request additional design narratives from the Designer and Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications. The requested data shall be provided in a timely manner.

7.13.5 These submittals to the CxA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CxA shall review them.

7.14 Construction Observations

7.14.1 Throughout construction, periodic construction observations shall be conducted by the CxA with the intent of verifying systems and equipment are being installed consistently and meet the Design Basis Report and design documents.

7.14.2 The CxA shall document the time, place and general information about the commissioning tasks conducted during these construction observations through Site Observation Reports. The CxA shall include comments upon miscellaneous observations not applicable to include in the Issues Log.

7.14.3 Major issues identified during the construction observations shall be documented on the Issues Log.

7.15 Commissioning Issues Log

7.15.1 The Commissioning Issues Log shall serve as an ongoing record of identified deficiencies, problems or concerns pertaining to the commissioned systems or individual pieces of equipment. The Issues Log identifies where the responsible party has deviated from the Design

Basis Report, Contractor's Agreement, applicable codes or normal industry practices.

7.15.2 The issue log shall have a section which is used by the Contractor to provide information and feedback requested by the CxA. The section includes:

7.15.2.1 Response: This is the CM or contractor(s) response to the issue identified by the CxA.

7.15.2.2 Responsible Party: Identifies the specific contractor responsible for correcting the issue.

7.15.2.3 The CxA shall be responsible for the maintenance of the Issues Log.

7.16 Start-up, Pre-functional Checklists and Initial Checkout

7.16.1 CxA shall apply the following procedures to all equipment to be commissioned, as listed below under "Systems to be Commissioned" Article.

7.16.2 The pre-functional testing for a given system must be successfully completed prior to formal Functional Performance Testing of equipment or subsystems of the given system.

7.16.3 Pre-Functional Checklists and Startup:

7.16.3.1 The commissioning team members responsible for startup of any equipment will assist the CxA in developing detailed start-up plans.

7.16.3.2 The primary role of the CxA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed.

7.16.3.3 Parties responsible for pre-functional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements in Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems".

7.16.3.4 The CxA shall adapt, if necessary, the representative pre-functional checklists and procedures from Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems". These checklists indicate required procedures to be executed as part of startup and checkout of the systems and identifies the party responsible for their execution.

7.16.3.5 The CxA shall develop a full start-up and checkout plan by combining or adding to the checklists provided by the manufacturer's detailed start-up and checkout procedures included in the O&M manual and the normally used field

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

7.16.3.6 The CxA shall provide the checklists to the Contractor. The Contractor will determine which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.

7.16.4 Sensor and Actuator Calibration:

7.16.4.1 All field-installed temperature, relative humidity, CO, CO_2, NO_x, enthalpy, pressure sensors, gages, and actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated.

7.16.4.2 All procedures used shall be fully documented on the pre-functional checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.

7.16.4.3 Sensor Calibration Methods – All Sensors:

7.16.4.3.1. Verify that all sensor locations are appropriate and away from causes of erratic operation.

7.16.4.3.2. Verify that sensors with shielded cable are grounded only at one end.

7.16.4.3.3. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the measurement range (not the sensor range) of each other, for pressure.

7.16.4.3.4. Tolerances for critical applications shall be tighter.

7.16.4.4 Sensor Calibration Methods - Sensors without Transmitters/Standard Application.

7.16.4.4.1. Make a reading with a calibrated test instrument within 6 inches of the site sensor.

7.16.4.4.2. Verify that the sensor reading (via the permanent thermostat, gage or Building Automation System (BAS)) is within the tolerances listed in the table below (with respect to the instrument-measured value in step-1).

7.16.4.4.3. If sensor reading is not within the required tolerance, install offset in BAS, calibrate or

replace sensor depending on the type of sensor. Repeat process to ensure that the sensor is reading within the required tolerance.

7.16.4.5 Sensor Calibration Methods - Sensors with Transmitters/Standard Application:

7.16.4.5.1. Disconnect the sensor.
7.16.4.5.2. Connect a signal generator in place of the sensor.
7.16.4.5.3. Connect ammeter in series between transmitter and BAS control panel.
7.16.4.5.4. Using manufacturer's resistance/temperature data simulate minimum desired temperature.
7.16.4.5.5. Adjust transmitter potentiometer zero until the ammeter reads 4mA.
7.16.4.5.6. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS.
7.16.4.5.7. Record all values and recalibrate controller as necessary to conform to specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction.
7.16.4.5.8. Reconnect sensor.
7.16.4.5.9. Make a reading with a calibrated test instrument within 6 inches of the site sensor.
7.16.4.5.10. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances listed in the table below (with respect to the instrument-measured value in step 1).
7.16.4.5.11. If not, replace sensor and repeat.
7.16.4.5.12. For pressure sensors, perform a similar process with a suitable signal generator.

7.16.4.6 Sensor Calibration Methods - Critical Applications:

7.16.4.6.1. For critical applications (process, manufacturing, etc.) more rigorous calibration techniques shall be required.

7.16.4.7 Tolerances for Sensor Calibration Methods for Standard Applications:

No	*Sensor*	*Required Tolerance (±)*
1.	Cooling coil, chilled and condenser water temps	0.1ºF
2.	AHU wet bulb or dew point	1.0ºF
3.	Hot water coil and boiler water temp	0.1ºF

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No	*Sensor*	*Required Tolerance (±)*
4.	Outside air, space air, duct air temps	0.1ºF
5.	Watt/hour, voltage & amperage	1% of design
6.	Pressures of air, water and gas	0.2% of full scale of measurement device
7.	Flow rates, air	2.5% of design
8.	Flow rates, water	0.5% of design parameter
9.	Relative humidity	3% of design
10.	Relative humidity, critical applications	2% of design
11.	Combustion flue temps	5.0 ºF
12.	Oxygen or CO_2 monitor	30 ppm + 2% of reading
13.	CO monitor	5% of Full Scale
14.	Natural gas and oil flow rate	1% of design
15.	Steam flow rate	3% of design
16.	Barometric pressure	0.1 in. of Hg

7.16.5 Valve and Damper Stroke Setup and Check

7.16.5.1 For all valve and damper actuator positions checked, verify the actual position against the BAS readout.
7.16.5.2 Set pumps or fans to normal operating mode.
7.16.5.3 Command valve or damper closed.
7.16.5.4 Visually verify that valve or damper is closed and adjust output zero signal as required.
7.16.5.5 Command valve or damper open.
7.16.5.6 Verify position is full open and adjust output signal as required.
7.16.5.7 Command valve or damper to a few intermediate positions.
7.16.5.8 If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).
7.16.5.9 For valves and dampers equipped with end switches, verify the actual position against the BAS switch status readout.
7.16.5.10 Closure for heating coil valves (Normally Closed - NC):

7.16.5.10.1. Set heating set point 20°F above room temperature.
7.16.5.10.2. Observe valve open.

7.16.5.10.3. Remove power from the valve and verify that the valve closes (check stem and actuator position).
7.16.5.10.4. Restore to normal.
7.16.5.10.5. Set heating set point to 20°F below room temperature.
7.16.5.10.6. Observe the valve close.
7.16.5.10.7. Restore to normal.

7.16.5.11 Closure for cooling coil valves (NC):

7.16.5.11.1. Set cooling set point 20°F above room temperature.
7.16.5.11.2. Observe the valve close.
7.16.5.11.3. Remove power from the valve and verify that the valve stem and actuator position do not change.
7.16.5.11.4. Restore to normal.
7.16.5.11.5. Set cooling set point to 20°F below room temperature.
7.16.5.11.6. Observe valve open.
7.16.5.11.7. Restore to normal.

7.16.6 Execution of Pre-Functional Checklists and Startup

7.16.6.1 Four weeks prior to startup, the CxA shall schedule startup and checkout with the Contractor (including Subcontractors and vendors) and Company.
7.16.6.2 The Pre-Functional Checklists will be executed by the Subcontractor or vendor. All Subcontractors that checked off items on the Pre-Functional Checklists will be required to provide a signature to verify the completion of their work.
7.16.6.3 The CxA may observe and verify the procedures as follows:

7.16.6.3.1. Observe or verify each piece of equipment for single units.
7.16.6.3.2. For multiple units, sampling strategy established by the CxA may be used.
7.16.6.3.3. For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CxA shall verify a sampling of the pre-functional and start-up procedures. The sampling procedures are identified in the commissioning plan.

7.16.7 Deficiencies, Non-Conformance and Acceptance of Checklists and Startup

7.16.7.1 The CxA shall review and verify the checklists and submit either a non-compliance report or an acceptance form to the Contractor and the Company.
7.16.7.2 The CxA shall work with the Contractor to correct and retest deficiencies or uncompleted items.

7.16.7.3 When satisfactorily completed, the CxA shall recommend acceptance of the execution of the checklists and startup of each system to the Company.

7.17 Phased Commissioning

7.17.1 The project may require startup and initial checkout to be executed in phases. This phasing shall be planned and scheduled in a coordination meeting attended by CxA, Company, the Contractor and the Subcontractors responsible for the systems being commissioned.

7.17.2 Phasing decisions resulting from the meeting shall be added to the Contractor's master and commissioning schedule.

7.18 Functional Performance Testing

7.18.1 The following applies to all Commissioning Functional Performance Testing for the project.

7.18.2 The general list of equipment to be commissioned is found in this section. The specific equipment and modes to be tested are found in Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems".

7.18.3 The parties responsible to execute each test are listed in Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems".

7.18.4 Objectives and Scope:

7.18.4.1 The objective of Functional Performance Testing is to demonstrate that each system is operating according to the documented Design Basis Report and Agreement.

7.18.4.2 Functional Performance Testing facilitates bringing the systems from a state of static completion to full dynamic operation.

7.18.4.3 During the testing process, areas of deficient performance are identified and corrected, improving the operation and function of the systems.

7.18.4.4 Each system shall be driven through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part-load and full-load) where system response is specified. Verification of each sequence listed in the sequences of operation document shall be performed.

7.18.4.5 Proper responses to specific modes and conditions such as power failure, freeze protection, low oil pressure, no flow, equipment failure, etc. shall also be tested. Specific modes required in this project are given in Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems".

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7.18.4.6 Functional Performance Testing witnessed by the CxA shall be considered successful when repeatable and acceptable outcomes meeting the Design Basis Report criteria are achieved.

7.18.5 Development of Test Procedures:

7.18.5.1 Prior to developing test procedures, the CxA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including a current (updated) points list, control sequences, schedules and set points.

7.18.5.2 Using the testing parameters and requirements of Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems" the CxA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system.

7.18.5.2.1. Prior to execution, the CxA shall provide a copy of the test procedures to the Contractor and vendors (for Company furnished equipment) for review and acceptance. The Contractor and their vendors will review the tests for feasibility, safety, equipment protection and warranty. If no comments are received from the Contractor, Subs. And vendors within one week of issuance, the Functional Performance Test procedures will be deemed as accepted.

7.18.5.2.2. The CxA shall also submit the tests to the Company and Designer for review and acceptance.

7.18.5.3 The CxA shall review Company-contracted, factory testing or required Company acceptance tests which the CxA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications.

7.18.5.4 The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form. The test procedure forms developed by the CxA shall include (but not be limited to) the following information:

7.18.5.4.1. Date
7.18.5.4.2. Project name
7.18.5.4.3. Participating parties and their respective role
7.18.5.4.4. System and equipment or component name(s)
7.18.5.4.5. Equipment location and ID number

7.18.5.4.6. Unique test ID number, and reference to unique pre-functional checklist and start-up documentation ID numbers for the piece of equipment
7.18.5.4.7. A copy of the specification section describing the test requirements
7.18.5.4.8. A copy of the specific sequence of operations or other specified parameters being verified
7.18.5.4.9. Formulas used in any calculations
7.18.5.4.10. Required pre-test field measurements
7.18.5.4.11. Instructions for setting up the test
7.18.5.4.12. Special cautions, alarm limits, etc.
7.18.5.4.13. Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
7.18.5.4.14. Acceptance criteria for proper performance and a "Yes/No" check box for documenting that the test was successful.
7.18.5.4.15. A section for notes and comments

7.18.6 Test Methods.

7.18.6.1 Functional Performance Testing and verification may be achieved by manual testing or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers or a combination of both methods.
7.18.6.2 Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems" specify which methods shall be used for each test.
7.18.6.3 The CxA may substitute specified methods or require an additional method to be executed, other than what was specified in Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems". The CxA shall determine during the development of the Commissioning plan methods that are most appropriate for tests that do not have a method specified.
7.18.6.4 Simulated Conditions:

7.18.6.4.1. Simulating conditions shall be allowed; though timing the testing to experience actual conditions shall be used wherever practical. Before simulating conditions, sensors, transducers and devices must be calibrated.

7.18.6.5 Overwritten Values:

7.18.6.5.1. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be

allowed, but shall be used with caution and avoided when possible. Before simulating conditions, sensors, transducers and devices must be calibrated.

7.18.6.6 Simulated Signals:

7.18.6.6.1. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is the preferred method over using the sensor to act as the signal generator via simulated conditions or overwritten values.

7.18.6.7 Altering Set points:

7.18.6.7.1. Rather than overwriting sensor values, altering set points to test a sequence shall be used where possible.

7.18.6.8 Indirect Indicators:

7.18.6.8.1. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during Pre-Functional Testing.

7.18.6.9 Setup:

7.18.6.9.1. Each function and test shall be performed under conditions that simulate real operating conditions as close as is practically possible.

7.18.6.9.2. The Subcontractors executing the test will provide all necessary materials and equipment, system modifications and temporary set-ups to produce the necessary flows, pressures, temperatures and other process variables as necessary to execute the test according to the specified conditions.

7.18.6.9.3. At completion of the tests, the Subcontractors will return all building equipment and systems affected by the tests to their pre-test condition.

7.18.6.10 Sampling:

7.18.6.10.1. Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise

identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference.

7.18.6.10.2. The specific recommended sampling rates are specified with each type of equipment in Section Section 230800 "Commissioning of HVAC Systems" and Section 260800 "Commissioning for Electrical Systems".

7.18.6.10.3. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CxA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.

7.18.6.10.4. Sampling is allowed only for Functional Performance Testing. Refer to the specific Divisions of each system for allowable sampling rates. No sampling by Subcontractors is allowed in Pre-functional checklist execution.

7.18.7 Coordination and Scheduling:

7.18.7.1 The CxA shall schedule Functional Performance Testing through the Contractor and his Subcontractors. The CxA shall direct, witness and document the Functional Performance Testing (FPT) of equipment and systems. The Subcontractors shall execute the tests.

7.18.7.2 General

7.18.7.2.1. Functional Performance Testing is conducted after pre-functional testing and startup has been satisfactorily completed.

7.18.7.2.2. The BAS shall be sufficiently tested and accepted by the CxA before it is used for TAB or to verify performance of other components or systems.

7.18.7.2.3. The air and water balancing shall be completed and accepted before Functional Performance Testing of air-related or water-related equipment or systems.

7.18.7.2.4. Testing shall proceed from components to subsystems to systems.

7.18.7.2.5. When the proper performance of all interacting, individual systems has been achieved, the interface or coordinated responses between systems shall be checked.

7.18.7.3 Problem Solving:

7.18.7.3.1. The CxA shall recommend solutions to problems found; however, the complete responsibility to solve, correct and retest problems is with the Contractor, Subs and the Designer.

7.19 Documentation, Non-Conformance and Acceptance of Tests

7.19.1 Documentation:

7.19.1.1 The CxA shall witness and document the results of all Functional Performance Tests using the specific procedural forms developed for that purpose. Prior to testing, these forms shall be provided to the CM, the Contractor, and to the Subcontractors for review and acceptance. The CxA shall include the filled-out forms in the O&M manuals.

7.19.2 Non-Conformance:

7.19.2.1 The CxA shall record the results of the Functional Tests on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the Company.

7.19.2.2 Corrections of minor deficiencies identified may be made during the tests at the discretion of the CxA. In such cases the deficiency and resolution will be documented on the procedure form.

7.19.2.3 Every effort will be made to expedite the testing process and minimize unnecessary delays while not compromising the integrity of the procedures. However, the CxA shall not waiver the responsibility of documenting deficiencies under any conditions. The authority to determine, modify or loosen the acceptance criteria in order to satisfy scheduling or cost issues lies with the Company and must be communicated in writing.

7.19.2.4 As tests progress, when a deficiency is identified, the CxA shall discuss the issue with the Contractor and his Subcontractor(s).

7.19.2.5 When there is no dispute on the deficiency and the Contractor accepts responsibility to correct it:

7.19.2.5.1. The CxA shall document the deficiency and the Subcontractor's response and intentions on a non-compliance form and the testing process resumes. The CxA shall submit the non-compliance reports to the Company and a copy to the Subcontractor.

7.19.2.5.2. The Subcontractor corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CxA.

7.19.2.5.3. The CxA shall reschedule the test and the test is repeated.

7.19.2.6 If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:

7.19.2.6.1. The deficiency shall be documented on the non-compliance form with the Subcontractor's response and a copy given to the Company and to the Subcontractor assumed to be responsible. Testing shall proceed to the next step or sequence.

7.19.2.6.2. Resolutions shall be made at the lowest management level possible. Other parties are brought into the discussions as needed.

7.19.2.6.3. Final interpretive authority is with the Designer. Final acceptance authority is with the Company. The CxA shall document the resolution process.

7.19.2.6.4. Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CxA. The CxA shall reschedule the test and the test is repeated until satisfactory performance is achieved.

7.19.3 Acceptance:

7.19.3.1 The CxA shall note each satisfactorily demonstrated function on the test form. Formal acceptance of the functional performance test shall be made later after review by the CxA and Company.

7.19.3.2 The CxA shall recommend acceptance of each test to the Company using a standard form.

7.19.3.3 The Company shall give final acceptance on each test using the same form, providing a signed copy to the CxA and the Contractor.

7.20 Operation and Maintenance Manuals

7.20.1 Standard O&M Manuals:

7.20.1.1 The specific content and format requirements for the standard O&M manuals are detailed in Construction Agreement Attachment A-1 Scope of Work. Special requirements for the controls contractor and TAB contractor are found Section 23 08 00 "Mechanical Systems

7.20.1.2 CxA Review and Acceptance:

7.20.1.2.1. Prior to substantial completion and after the Designer has reviewed the O&M manuals, the CxA shall review the O&M manuals,

documentation and redline as-built for systems that were commissioned to verify compliance with the Agreement Specifications.

7.20.1.2.2. The CxA shall communicate deficiencies in the manuals to the Company and Designer.

7.20.1.2.3. Upon a successful review of the corrections, the CxA shall recommend acceptance of these sections of the O&M manuals to the Company. The CxA shall also review each equipment warranty and verifies that all requirements to keep the warranty valid are clearly stated.

7.20.1.2.4. The CxA review does not supersede the Designer's review of the O&M manuals and as-built according to the Designer's contract.

7.20.2 Systems Manual:

7.20.2.1 The CxA shall compile, organize and index the following commissioning data by equipment into a labeled, indexed and tabbed multiple file composite electronic PDF file and deliver it to the Company. The format of the manual shall be:

No.	*TAB*	*Subject*
1.	Tab 1	Commissioning Plan
2.	Tab 2	Final Commissioning Report
3.	Tab 3-1	System #1 (Example: Chilled Water System)
4..	Tab 3-2	Design narrative and criteria, sequences, acceptance for System-1 equipment
5.	Tab 3-3	Startup plan and report, acceptance, corrections, blank pre-functional checklists with colored separator sheets for each equipment type (fans, pumps, chiller, etc.)
6.	Tab 3-4	Functional tests (completed), trending and analysis, acceptance and corrections, training plan, record and acceptance, blank functional test forms and a recommended re-commissioning schedule
7.	Tab 4-1	System #2 (Example: Hot Water System)
8.	Tab 4-2	Repeat per Tab 3-2, Etc…

7.20.3 Final Report Details:

7.20.3.1 The final commissioning report shall include an executive summary, list of participants and roles, brief building

description, overview of commissioning and testing scope and a general description of testing and verification methods.

7.20.3.2 For each piece of commissioned equipment, the report shall contain the disposition of the CxA regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:

7.20.3.2.1. Equipment meeting the equipment specifications
7.20.3.2.2. Equipment installation
7.20.3.2.3. Functional performance and efficiency
7.20.3.2.4. Equipment documentation and design intent
7.20.3.2.5. Operator's training.

7.20.3.3 All outstanding non-compliance items referred to specific functional tests, inspections, trend logs or other processes where the deficiencies are documented shall be specifically listed.

7.20.3.4 Recommendations for improvement to equipment or operations, future actions, commissioning process changes and other pertinent information shall also be listed.

7.20.3.5 The functional performance and efficiency section for each piece of equipment shall include a brief description of the verification method used (manual testing, BAS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

7.20.3.6 The CxA shall retain all other documentation.

7.21 Training of Company Personnel

7.21.1 Responsibilities

7.21.1.1 The CM shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.

7.21.1.2 The CxA shall be responsible for overseeing and approving the content and adequacy of the training of Company personnel for commissioned equipment.

7.21.2 Procedures

7.21.2.1 The CxA shall develop an overall training plan.

7.21.2.2 The CM shall coordinate and schedule the overall training for the commissioned systems with the Company and Contractor.

7.21.2.3 The CxA shall develop criteria for determining that the training was satisfactorily completed. This could include attending some of the training sessions.

7.21.2.4 The CxA shall interview the facility manager and lead engineer to determine the special needs and areas where training will be most valuable. The Company and CxA shall

decide how rigorous the training should be for each piece of commissioned equipment.

7.21.2.5 The Contractor shall develop the training agendas. The agendas are reviewed and accepted by the CxA and Company.

7.21.2.6 If requested by the CxA, each Subcontractor and vendor responsible for training shall submit a written training plan to the CxA for review and acceptance prior to training. The plan shall cover the following elements:

7.21.2.6.1. Equipment (included in training)
7.21.2.6.2. Intended audience
7.21.2.6.3. Location of training
7.21.2.6.4. Objectives
7.21.2.6.5. Subjects covered (description, duration of discussion, special methods, etc.)
7.21.2.6.6. Duration of training on each subject
7.21.2.6.7. Instructor for each subject and Instructor qualifications
7.21.2.6.8. Training methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

7.21.2.7 Personnel employed by Contractors, Subcontractors and equipment distributors are not approved for training. Only qualified employees of the manufacturer can perform training, subject to acceptance by the CxA and Company.

7.21.2.8 Once the agendas are accepted, the CxA shall sign the forms and transmit the agendas to the trainees, Subcontractors and Manufacturers who have training responsibilities. The agendas are used during the training sessions and are signed by the trainees at the end of each session.

7.21.3 Training Scope

7.21.3.1 In addition to these general requirements, the specific training requirements of Company personnel by Subcontractors and vendors is specified in Division 22, 23 and 26.

7.21.3.2 The CxA shall arrange for the Designer shall at the first training session present the overall system(s) design concept and the design concept of each equipment section. This presentation shall include a review of all systems using the simplified system schematics (single-line drawings) including chilled water systems, condenser water or heat rejection systems, heating systems, fuel oil and gas supply systems, supply air systems, exhaust system, outside air and sustainable design strategies.

7.21.3.3 The CxA shall arrange for the Contractor for the primary HVAC equipment to provide a short discussion of the control of the equipment during the mechanical or electrical training.

7.21.3.4 At one of the training sessions, the CxA shall discuss the use of the blank functional test forms for re-commissioning equipment.

7.21.3.5 The Contractor will provide videotaping (on DVD) of the training sessions with tapes cataloged and added to the O&M manuals.

7.21.4 Deferred Testing:

7.21.4.1 Unforeseen Deferred Tests:

7.21.4.1.1. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon acceptance of the Company. These tests will be conducted in the same manner as the seasonal tests as soon as possible.

7.21.4.2 Seasonal Testing:

7.21.4.2.1. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in Section 230800 "Commissioning of HVAC Systems" shall be completed as part of this contract. The CxA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subcontractors, with Company and the CxA witnessing. Any final adjustments to the O&M manuals and as-builts due to the testing shall be made.

7.22 Written Work Products

7.22.1 The commissioning process generates many written work products described in various parts of the Specifications. The Construction Phase Commissioning Plan shall list all the formal written work products, briefly describe their contents, who is responsible to create them, their due dates, who receives and accepts them and the location of the specification to create them.

7.22.2 In summary, the written products are:

Item #	*Product*	*Developed/Submitted By:*
1.	Commissioning plan	CxA
2.	Commissioning meeting minutes	CxA

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Item #	*Product*	*Developed/Submitted By:*
3.	Commissioning schedules	CM & GC with input from CxA
4.	Equipment documentation submittals	Contractor/Subcontractors
5.	Sequence clarifications	Designer and Contractor/ Subcontractors as needed
6.	Pre-functional checklists	CxA with input from Manufacturers
7.	Startup and initial checkout plan documents	CxA with input from Manufacturers
8.	Startup and initial checkout forms completed	Subcontractors and Manufacturers
9.	Final TAB report	TAB Contractor
10.	Issues log (deficiencies)	CxA
11.	Commissioning Progress Record	CxA
12.	Deficiency reports	CxA
13.	Functional Performance Test Procedures	CxA
14.	Functional Performance Tests Results	CxA
15.	O&M manuals	Contractor/Subcontractors
16.	Commissioning record	CxA
17.	Overall training plan	CxA and Company
18.	Specific training agendas	CxA with input from Contractor/Subcontractors and Company
19.	Final commissioning report	CxA
20.	Acceptance of Miscellaneous Items	CxA

7.23 Systems to be Commissioned: The following systems shall be commissioned in this project.

7.23.1 Pipeline, Tunnel Ventilation

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Item #	*Equipment and System*
1.	NS Fan Plant
2.	MS Fan Plant

7.23.2 Controls/BMS

Item #	*Equipment and System*
1.	Gas Detection
2.	PLC
3.	PLC to MS LAN
4.	PLC MS to NS connectivity
5.	PLC to NS LAN
6.	PLC to Mid tunnel Sump
7.	MS Electrical System Monitoring
8.	NS Electrical System monitoring

7.23.3 HVAC

Item #	*Equipment and System*
1.	Balance Circulation Fans
2.	Shaft Ventilation
3.	Control Room VRF System
4.	NS Building VRF System
5.	MS Building VRF Systems

7.23.4 Fire Protection

Item #	*Equipment and System*
1.	MS Standpipe
2.	NS Standpipe

7.23.5 Plumbing

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Item #	*Equipment and System*
1.	NS Sumps
2.	Mid tunnel Sumps
3.	MS sumps
4.	MS Water Treatment
5.	MS Water Heaters
6.	MS Expansion Tank

7.23.6 Civil

Item #	*Equipment and System*
1.	MS Septic
2.	MS Tunnel Discharge/ OWS
3.	MS Well Water Supply
4.	MS Discharge to Lake
5.	NS discharge to Lake

7.23.7 IT/Security

Item #	*Equipment and System*
1.	NS LAN
2.	NS LAN to ENB
3.	MS LAN
4.	MS LAN to ENB
5.	MS to NS Fiber Connection
6.	Tunnel WAN
7.	MS-NS interconnection through ENB network
8.	Tunnel Fixed Telephone System
9.	Tunnel Radiating Cable
10.	NS CCTV
11.	MS CCTV

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Item #	*Equipment and System*
12.	NS Access control
13.	MS Access Control

7.23.8 Electrical

Item #	*Equipment and System*
1.	NS Normal System
2.	NS Emergency System (Generator/ATS)
3.	MS Normal System
4.	MS Emergency System (Generator/ATS)
5.	NS tunnel substation
6.	MS Tunnel Substation
7.	Lighting
8.	NS Interior Lighting control System
9.	NS Exterior Lighting control System
10.	MS Interior Lighting control System
11.	MS Exterior Lighting control System
12.	NS Lightning Protection System
13.	MS Lightning Protection System
14.	NS Fire Alarm and Detection
15.	MS Fire Alarm and Detection

7.23.9 Other

Item #	*Equipment and System*
1.	Elevator
2.	Hoist
3.	TSV Chargers
4.	TSV Auxiliary equipment

8.0 Responsibilities of Other Parties

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8.1 The responsibilities of various others parties in the commissioning process are provided in this section.

8.2 The Commissioning team and others involved in the Commissioning process shall follow the Commissioning Plan and attend the Commissioning scoping meeting and any additional meetings, as necessary.

8.3 Designer:

8.3.1 Design Phase

8.3.1.1 Develops the Design Basis Report and provides it to the CxA. CxA will review for accuracy, clarity, completeness, and alignment with the Design Basis Report.

8.3.1.2 Review Commissioning specifications prior to incorporation into design documents.

8.3.2 Construction and Acceptance Phase

8.3.2.1 Review the Commissioning plan.

8.3.2.2 Attend Commissioning Scoping Meeting and other Commissioning team meetings as requested by the CxA and additional meetings as selected by the Designer.

8.3.2.3 Provide any design narratives, calculations, Design Basis Report, sequence of operations and any other requested information by the CxA.

8.3.2.4 Perform submittals review, construction observations, record drawing preparation, and operations and maintenance data preparation as required by the Agreement. On site observation should be completed just prior to system startup. Copy of all documents and reports issued by the Designer must be provided to the CxA.

8.3.2.5 Respond to Requests for Information.

8.3.2.6 Review and accept the Pre-Functional Checklists for major pieces of equipment for sufficiency prior to their use.

8.3.2.7 Assist, along with the contractors, in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.

8.3.2.8 Review and accept the Functional Performance Test procedure for major pieces of equipment and systems for sufficiency prior to their use.

8.3.2.9 Participate in the resolution of design non-conformance and deficiencies identified during commissioning, as required by the contract documents.

8.3.2.10 Conduct site observations and generate punch lists.

8.3.2.11 Witness testing of selected pieces of equipment and systems as required by the CxA. Prepare and submit the final as-built design intent and operating parameters documentation for inclusion in the O&M manuals. Review

and accept the O&M manuals provided by the contractors and vendors.

8.3.2.12 Review the commissioning log and respond to all items in a timely manner.

8.3.2.13 Review and comment on the Final Commissioning report.

8.3.2.14 Provide a presentation of the MEP systems design at one of the training sessions for the Company's personnel.

8.3.3 Warranty Period

8.3.3.1 Coordinate the resolution of design non-conformance and design deficiencies identified during warranty-period commissioning.

8.4 Company

8.4.1 General

8.4.1.1 Manage the contract of the Designer, GC, CxA and CM.

8.4.1.2 Provide interpretations and clarifications of the Design Basis Report or similar documentation.

8.4.1.3 Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions as outlined in the Commissioning Plan or Agreement.

8.4.1.4 Assist in coordination of site observations and meetings with the Commissioning Authority, as required.

8.4.1.5 Review and comment on commissioning documentation such as but not limited to the Commissioning Plan, Site Observation Reports, Commissioning Issues Log, Functional Performance Testing (FPT) Reports and Final Commissioning Report.

8.4.1.6 Provide input and direction on commissioning-related recommendations arising from the commissioning process which may enhance the operation of the facility but are not included in the project documents. If the Company agrees with commissioning recommendations, they are to direct the Designer to review and issue appropriate directive to add scope and maintain the Designer's responsibility for all construction documents.

8.4.1.7 Provide final acceptance for completion of the commissioning work.

8.4.2 Construction and Acceptance Phase

8.4.2.1 Review the Commissioning Plan.

8.4.2.2 Facilitate the coordination of all commissioning activities. Ensure that commissioning activities are being scheduled into the Contractor's Construction schedule.

8.4.2.3 Attend the commissioning scoping meeting and all subsequent Commissioning team meetings.

WARNING: Not part of Contractor's Scope of Work. Provided for information on and for coordination purposes with Commissioning Authority's scope only

8.4.2.4 Perform the normal review of Contractor submittals.

8.4.2.5 Furnish a copy of all construction documents, addenda, change orders, accepted submittals and shop drawings related to Commissioned equipment to the CxA.

8.4.2.6 Arrange for facility operating and maintenance personnel to attend various field Commissioning activities and schedule the training sessions according to the construction phase commissioning plan and the specifications.

8.4.2.7 Review and accept the Functional Performance Test procedures submitted by the CxA, prior to testing.

8.4.2.8 When requested by the CxA or otherwise determined to be required by the Company, observe and witness Pre-Functional testing, start-up and Functional Performance Testing of selected equipment.

8.4.2.9 Review Commissioning progress and deficiency reports issued by the CxA. Coordinate the resolution of construction and design deficiencies identified in all phases of commissioning.

8.4.3 Warranty Period

8.4.3.1 Assist the CxA as necessary in the seasonal or deferred testing and deficiency corrections required by the specifications.

8.5 Contractor's Responsibilities: As required in the Contractor's Agreement.