SECTION 019113 - GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 OVERVIEW

A. This section of the specification describes the process for commissioning and defines the responsibilities of the commissioning agent, the contractors, and outlines the duties of other members of the commissioning team.

B. The commissioning process shall be applied to all equipment, components, and systems as listed in this section, including specific interfaces to and from equipment and systems provided under separate contracts.

C. Building Commissioning work is a joint team effort to ensure that all systems function together properly to meet the design intent, and to document system performance parameters for fine-tuning of control sequences and operations procedures. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, training, and performance testing. This section does not supersede other requirements of the specifications. It may, though, expand on some of them.

1.2 COMMISSIONING AGENT

A. The Commissioning Agent (CA) will be an independent 3rd party engaged by the General Contractor.

1.3 STANDARD AND CODE COMPLIANCE

A. Commissioning will be accomplished to comply with, and in accordance with the requirements of the following:

1. 2020 Energy Conservation Construction Code of New York State, Section C408 System Commissioning.

1.4 THE COMMISSIONING TEAM

A. The commissioning team shall consist of:

1. Commissioning Agent (CA).
2. HVAC Contractor (HC).
3. Plumbing Contractor (PC).
4. Electrical Contractor (EC).
5. General Contractor (GC).
6. Fire Protection Contractor (FPC).

7. All appropriate Contractors and Sub-Contractors including but not limited to; temperature controls, sheet metal, testing and balancing, fire alarm fire protection and elevator installer.

8. Approved Representatives of Mechanical, Electrical and Equipment Manufacturers.

9. Design Engineers (DE).

10. Design Architect (ARCH).

11. Facility Staff (FS).

12. Owner's Representative (OR).

1.5 COORDINATION

A. Project Commissioning Team - The members of the Project Commissioning Team shall consist of the Commissioning Authority and any support personnel, the Owner's facility staff (FS) or designee, the HVAC Contractor, Electrical Contractor, Plumbing Contractor, Fire Alarm Contractor, Fire Protection Contractor, General Contractor, Elevator Vendor, or additional vendors as required, the Architect/Engineer (A/E) and Owner's Representative (OR).

B. Management - The CA coordinates the commissioning activities through the Owner's Representative (OR). All members shall work together to fulfill their contracted responsibilities and meet the objectives of the contract documents. Refer to Paragraph 1.6 for additional management details.

C. Scheduling - The CA, through the OR, will provide sufficient notice to the Contractors for scheduling commissioning activities with respect to the Owner's participation. The Contractors will integrate all commissioning activities into the overall project schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

1.6 COMMISSIONING PLAN

A. The CA will develop the Commissioning Plan which shall be included in the project schedule when approved by the Owner.

B. The Commissioning Plan shall contain the information necessary to document the commissioning process as it progresses from pre-start checks, to start-up and initial operation, and finally to functional performance verification of all systems.

C. The Commissioning Plan shall also contain a schedule of commissioning work, integrated with the overall project schedule. This schedule shall show:

1. Completion dates for each system or systems in each area of the building.

2. Dates for controls installation completion and point checkout.

3. Dates for carrying out Steps 1 and 2 commissioning work for each system or group of systems.

4. Submission dates for the documentation required by the Engineer prior to Step 3 verification.

5. Dates for carrying out Step 3 commissioning work.

D. The following narrative provides a brief overview of the commissioning tasks that shall be performed during construction and the general order in which they occur.

1. Commissioning during construction begins with an initial commissioning meeting conducted by the CA where the commissioning process is reviewed with the project commissioning team members.

2. Additional meetings will be required throughout construction, scheduled by the CA, through the Owner or OR, with necessary parties attending to plan, scope, coordinate, schedule future activities and address issues.

3. Equipment documentation is submitted to the CA, through the Owner, OR, Architect, during normal submittals, including detailed startup procedures.

4. The prefunctional checklists, developed by the CA are to be completed by the Contractor (or its Subcontractors), before and during the startup process.

5. Prefunctional checklists, TAB and startup must be completed before performance testing.

6. Items of non-compliance in material, installation, or setup shall be corrected at no expense to the Owner.

7. The Contractor ensures that the Subcontractors' prefunctional checklists are executed and documented and that startup and initial checkout are performed. The CA verifies that the TAB, prefunctional checklists and startup were completed according to the approved plans. This includes the CA approving TAB, checklists and startup plans. This also includes witnessing startup of selected equipment. Any testing failure is to be corrected at no additional cost to the Owner, and a re-test is to be performed, observed, and documented.

8. The CA develops and implements equipment and system functional test procedures. The forms and procedures are approved by the Owner and A/E.

9. The performance tests are executed by the Contractor under the direction of the CA with the assistance of the facility staff. All documentation is by the CA.

10. The CA provides the Commissioning Record.

11. Commissioning is to be completed before substantial completion.

12. Deferred testing and/or seasonal verifications are to be conducted as specified or required.

1.7 COMMISSIONING RESPONSIBILITIES

A. Commissioning Agent:

1. Plan, organize, direct and implement the Commissioning Process as specified herein.

2. Prepare the Commissioning Plan and submit for review by the Owner and Architect.

3. Revise the Commissioning Plan as required during construction.

4. Chair commissioning meetings, prepare and distribute schedules and agendas for the meetings, and prepare and distribute minutes to all Commissioning Team members, whether or not they attended the meeting.

5. Write the prefunctional checklists, initial operation and functional test procedures and submit for review by the Owner. The test procedures and checklists should be designed to verify detailed aspects of the proper operation of all equipment items and overall system performance in accordance with the design intent of the systems.

6. Coordinate commissioning activities among all Contractors, sub-trades, and suppliers, and all related commissioning requirements in the various specifications for all contracts.

7. Carry out all required system readiness checks and document the results as the checks are done.

8. In cooperation with the Controls Subcontractor, ensure all control point checkouts are carried out and the results documented as the checks are done.

9. Observe or verify all start-ups and initial system operations tests and checks, which shall encompass all specified functional performance tests, ensuring the results are documented as the tests and checks are done.

10. Provide periodic site visits as required to observe system installation.

11. Maintain master issues log. Resolution to issues found shall be documented by installing contractor and submitted to CA.

12. At the direction of the Engineer, ensure equipment and systems are operated for functional performance verification purposes.

13. Ensure all required training and demonstrations are provided to the Owner's designated operating staff and that all Operations and Maintenance manuals are submitted, approved and provided to the Owner.

14. Develop a Final Commissioning Record.

15. Coordinate deferred/seasonal commissioning required.

B. Contractors:

1. Within four (4) weeks of the award of the contract, the HC, PC, GC, EC, FPC Contractors and relevant subcontractors shall submit the names of the Project Manager who will be the Commissioning Coordinator for this project, as well as the names, addresses, phone numbers and qualifications of Subcontractors' Representatives and factory trained Manufacturer's Representatives for all equipment and systems required to participate in the Commissioning Process as specified in this Section.

2. Each Contractor and all his sub-trades and suppliers, shall cooperate with the Commissioning Agent in carrying out the Commissioning Process. In this context, each Contractor shall:

a. Provide equipment and systems start-up as specified.

b. Operate equipment and systems as required for initial systems operations, and witness final functional performance tests as they are performed by the Commissioning Agent, including the on-site participation of approved factory trained Manufacturer's Representatives for equipment.

c. Attend commissioning meetings and attend to action items arising from them, as required to allow the Commissioning Process to proceed on schedule.

d. Provide instruction and demonstrations for the Owner's designated operating staff, in conjunction with the Commissioning Agent, in order to meet all specified training requirements in this regard.

e. The Contractors shall make any and all necessary corrections to systems, equipment, O & M manuals, as built drawings, and procedures as necessary to meet the design intent, contract documents, manufacturer's recommendations or performance requirements if errors are discovered during the Commissioning Process.

f. The Contractors shall supply all necessary documentation, such as shop drawings, submittal data, maintenance manuals, etc. required for equipment and systems, to the Commissioning Agent for preparation of the commissioning plan, checklists, and functional performance plans.

g. The Contractors shall provide the required names, addresses and qualifications of all specified Manufacturer's Representatives to participate in the Commissioning Process prior to the initial commissioning meeting.

h. Subsequent installation and performance verifications, made necessary due to required corrections after initial verification, shall be at the respective Contractor's expense.

i. Carry all commissioning related costs in contract bid price.

j. Review all documentation provided by CA and provide comments, if required prior to on site commissioning activities.

k. Engage, at Contractor's cost, any Manufacturer's Representatives required to complete start-up and commissioning activities.

l. Include cost of all devices and special tools to complete commissioning activities.

C. Manufacturer's Representatives:

1. The factory trained and authorized Manufacturer's Representatives shall participate in the commissioning process as specified in this section and as indicated in the technical section of the specifications.

2. Each Manufacturer's Representative shall cooperate with the commissioning agent in carrying out the commissioning process. In this context, each Manufacturer's Representative shall:

a. Provide equipment start-up as specified.

b. On-site participation as required for initial equipment operations and witness final functional performance tests as they are performed by the commissioning agent.

c. Attend commissioning meetings, as applicable and attend to action items arising from them, as required to allow the commissioning process to proceed on schedule.

d. Provide instruction and demonstrations for the Owner's designated operating staff, as specified in conjunction with the commissioning agent, in order to meet all specified training requirements in this regard.

e. Make any and all necessary corrections to equipment, O&M manuals, as-built drawings and procedures as necessary to meet the design intent, contract documents or performance requirements if errors are discovered during the commissioning process.

f. Subsequent installation and performance verifications, made necessary due to required corrections after initial verification, shall be at the respective manufacturer's expense.

D. Design Engineers and Architects:

1. Provide "Basis of Design" documentation inclusive of design criteria for CA review.

2. The Design Engineers and Architect shall review the Commissioning Plan, commissioning checklists and functional performance test plans. They shall also participate, as appropriate, in on-site commissioning meetings.

3. During the functional performance phase of the Commissioning Process, the Design Engineers and Architects may be on site to review commissioning documentation, witness functional performance tests, and verify acceptable performance or to declare performance unacceptable, as required.

4. Provide design narrative information to CA as required.

5. Participate in deficiency resolution process of items identified during Commissioning Process.

E. Owner's Representative (User):

1. Provide "Owner's Project Requirements" documentation for CA review.

2. The Owner shall ensure the availability of operating staff for all scheduled training and demonstration sessions. This staff shall possess sufficient skills and knowledge to operate and maintain the installation following attendance at these sessions.

3. Attend commissioning meetings.

4. Sign off of all accepted functional test procedures.

5. Participate in seasonal/deferred testing.

1.8 DESCRIPTION OF WORK

A. The "Systems and Equipment" as referred to in this section of the specifications shall include, but not be limited to, subsystems and components of subsystems; as provided by various contracts as follows:

1. HVAC Systems
2. Domestic Hot Water Equipment
3. Daylight/Dimming Controls
4. Lighting System, Scheduled Lighting Controls and Occupancy Sensors
5. Fire Protection Systems
6. Fire Alarm Systems
7. Plumbing Fixtures and Controls
8. Elevator Controls

1.9 COMMISSIONING PROCESS

A. The on-site commissioning process shall be organized and carried out in four (4) steps as follows:

1. Step 1 - System readiness and start-up.
2. Step 2 - Initial operation.
3. Step 3 - Functional performance verification.
4. Step 4 - Demonstration and instruction.

B. Each step is applicable to each separate system and its components, as listed in Part 3, including all related controls and specified interfaces to other divisions and contracts.

C. The Contractors shall review and verify the commissioning schedule and requirements for the interface between all trades in order to prevent delays in the Commissioning Process.

D. In some systems, improper adjustments, misapplied equipment, and/or deficient performance under varying loads may result in additional work being required to commission the systems. This work shall be completed under the direction of the General Contractor with input from the Contractors, Equipment Supplier, and Commissioning Agent. Whereas all members shall have input and the opportunity to discuss, debate, and work out problems, the Design Architect or Engineer shall have final jurisdiction over any additional work done to achieve performance.

E. Corrective work shall be completed in a timely fashion to permit the completion of the commissioning process. Experimentation to demonstrate system performance may be permitted. If the Commissioning Agent deems the experimentation work to be ineffective or untimely as it relates to the Commissioning Process, the Commissioning Agent shall notify the Owner, indicating the nature of the problem, expected steps to be taken, and suggestions for completion of activities. Costs incurred to solve the problems in an expeditious manner shall be the Contractor's responsibility.

F. Seasonal commissioning is required under full load conditions during peak heating and peak cooling seasons, as well as part load conditions in the spring and fall. Simulations of peak load conditions may be implemented to allow for complete commissioning of the work.

G. Systems that are not weather dependent shall be tested under full and partial load to the fullest extent possible.

1.10 STEP 1 - SYSTEMS READINESS AND START-UP

A. Before starting any equipment or systems, the Contractors shall complete the system readiness or pre-start checks in the commissioning plan and the Commissioning Agent shall document the results. The following conditions and items shall be completed as applicable:

1. Piping systems have been pressure tested as specified, found to be tight, with reports submitted.

2. Piping systems have been flushed and cleaned as specified, any required reports submitted, and then filled or charged as applicable.

3. Equipment has been lubricated to specification.

4. Air system cleaning is complete, and particulate filters have been installed.

5. Vibration isolation has been installed to specification and adjusted.

6. Equipment drives have been aligned.

7. Electrical, water and fuel services have been installed and checked.

8. Control point checkouts have been completed.

9. Safety controls have been installed and operation checked.

10. Major equipment start-up has been carried out by Manufacturer's Representative when specified and required startup reports completed and submitted.

B. All checks shall be documented on the relevant checklists as they are carried out. Deficiencies or incomplete work shall be corrected and the checks repeated until the installation is ready for operation before proceeding to Step 2 of the process.

1.11 STEP 2 - INITIAL OPERATION

A. In Step 2 of the Commissioning Process, the Contractors, with the Commissioning Agent verifying, complete the testing, balancing, and calibration of all components and systems. They also operate all systems through all specified modes of operation and test system responses to specified abnormal or emergency conditions.

B. Work carried out during this step of commissioning shall include but not be limited to, the following:

1. Air systems balancing, including positioning of all balance dampers, adjustments to diffusers, registers and grilles.

2. Hydronic systems balancing, including positioning of all balance valves.

3. Correction of problems revealed during balancing, including changes to fan speeds or blade pitch as necessary.

4. Setting up and calibrating all automatic temperature controls devices, including adjustments to control valves and damper actuators.

5. Setting up or programming controls for accurate response and precise sequencing to meet specified performance.

6. With Commissioning Agent verifying, the Balancing Contractor and Controls Contractor working together setting up airflows and controls calibrations for terminal units and airflow stations.

7. Ensuring final adjustments to vibration isolation are carried out as necessary.

C. As was done in Step 1, all checks and tests shall be documented on the relevant checklists as they are carried out. Deficiencies or incomplete work shall be corrected, and the checks or tests repeated until correct installation and function has been confirmed and the installation is ready for engineering verification.

1.12 STEP 3 - FUNCTIONAL PERFORMANCE TEST AND VERIFICATION

A. All equipment and systems shall be operated through the entire specified sequence of operations for witness and verifying acceptable operation, by the Commissioning Agent.

B. During this step of commissioning, the following checks and test shall be required:

1. Check the location and accessibility of all access panels.

2. Operation of all control system devices, both sensors and actuators.

3. Proper physical response of all controlled devices and components to setpoint changes or other relevant adjustments.

4. Operation of randomly selected motorized dampers.

5. Demonstration of acceptable noise and vibration levels from major equipment, under its full range of operational conditions.

6. Operation of equipment and systems under every specified mode of operation and sequence of control.

7. Once acceptable performance of systems has been verified, then verification of specified interfaces to/from equipment and systems provided under other divisions and contracts shall be performed.

1.13 STEP 4 - DEMONSTRATION AND INSTRUCTION

A. The formal demonstration and instruction for operating staff shall commence once the Step 3 commissioning is complete and substantial completion achieved.

B. Demonstration and instruction in accordance with the "Design Intent" shall cover all equipment and systems and their controls.

1.14 COMMISSIONING START-UP AND COMPLETION

A. Commissioning of certain systems may be required to be performed during both heating and cooling seasons. Commissioning shall be performed at the earliest such time as possible after substantial completion of each system.

1.15 REFERENCES

A. Systems commissioning shall be accomplished as specified and in accordance with the latest version of commissioning publications from one the following industry associations:

1. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) Guideline 1.1, HVAC&R Technical Requirements for the Commissioning Process.

2. Associated Air Balancing Council, Commissioning Reference Manual.

3. Building Commissioning Association - The Building Commissioning Handbook.

1.16 DOCUMENTATION

A. Each Contractor shall provide to the Commissioning Agent three (3) copies of the following items as soon as they become available:

1. Certified and approved start-up and testing report forms for all subsystem equipment that comprise the System. Commissioning documentation shall include control schematics of the total system and all subsystems.

2. Records of required inspections for code compliance, and documentation of approved permits and licenses to operate components of the System.

3. Operating data which shall include all necessary instructions to the Owner's operating staff in order to operate the system to specified performance standards.

4. Maintenance data which shall include all necessary information required to maintain all equipment in continuous operating condition, such as the testing, balancing and adjusting report and the as-built drawings.

5. Written notice that building equipment and systems have been completed, tested and are fully operational.

6. Checklist of all submitted contract deliverables such as; operation and maintenance manuals, spare parts, warranties, training, documentation, etc.

PART 2 - PRODUCTS

2.1 TESTING

A. The Contractor shall provide any equipment or device required for access such as platforms, scaffolds, and spare filters as may be necessary for all verification and testing.

B. All standard testing equipment required to perform startup and initial checkout and required performance testing shall be provided by the Contractor for the equipment being tested. This includes, but is not limited to, two-way radios, meters, and data recorders.

C. Special equipment, tools, and instruments required for testing equipment according to these contract documents shall be included in the Contractor's base bid price and shall be turned over to the Owner at project close-out.

D. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance within the tolerances specified in the specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration to NIST traceable standards within the past year to an accuracy of 0.5°F and a resolution of ± 0.1°F. Pressure sensors shall have an accuracy of ± 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 GENERAL

A. Each Contractor shall coordinate with the Commissioning Team in the construction phase of the project to assure compliance with all system commissioning requirements.

3.2 DESIGN CRITERIA AND INTENT

A. Design criteria and intent shall be as described in the technical specification sections and contract drawings. The basis of design developed by the Architect and Engineer will be also referenced.

3.3 MEETINGS

A. Initial Meeting:

1. The CA, through the OR, will schedule, plan and conduct an initial commissioning meeting. The Contractors and their responsible parties are required to attend.

B. Miscellaneous Meetings:

1. Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution, and planning issues. These meetings will be held to the extent possible following construction meetings to minimize additional travel for all parties.

3.4 STARTUP, CONSTRUCTION CHECKLISTS AND INITIAL CHECKOUT

A. The following procedures apply to all equipment/systems to be commissioned.

B. General: Prefunctional checklists are required to verify that the equipment and systems are fully connected and operational. It ensures that performance testing (in-depth system checkout) may proceed without unnecessary delays. The prefunctional checklists for a

given system must be successfully completed and approved prior to startup and formal performance testing of equipment or subsystems of the given system.

C. Startup and Checkout Plan: The CA will assist the Project Commissioning Team members responsible for startup of any equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer recommended procedures has been completed. The CA shall provide prefunctional checklists and startup shall be identified in the commissioning scoping meeting and on the checklist forms.

1. The prefunctional checklists will be developed by the CA and provided to the Contractors. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.

2. The Contractor shall determine which trade is responsible for executing and documenting each of the line item tasks and transmit the checklists to the responsible subcontractors. Each form may have more than one trade responsible for its execution.

3. The Contractor/Subcontractor responsible for the purchase of the equipment shall develop the full startup plan by combining the manufacturer's detailed startup and checkout procedures and the prefunctional checklists.

4. The Contractor/Subcontractor shall submit the full startup plan to the CA for review and approval.

5. The CA will review and approve the procedures and the documentation format for reporting. The CA will return the procedures and the documentation format to the Contractor.

6. The Contractor will transmit the full startup plan to the Subcontractors for their review and use.

D. Sensor and Actuator Calibration: All field-installed temperature, relative humidity, CO, CO_2, refrigerant, O_2, and/or pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated. Verify that all locations are appropriate and away from causes of erratic operation. Submit to the CA the calibration methods and results. All test instruments shall have had a certified calibration within the last six (6) months to NIST traceable standards, and comply with all local, state and/or federal requirements/certifications, as required. Sensors installed in the unit at the factory with calibration certification provided need not be field calibrated. Provide bench testing as required at the direction of the CA.

1. Sensor Calibration Methods:

a. All Sensors - Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable, are grounded only at one end. 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 reading, of each other, for pressure. Tolerances for critical applications may be tighter.

b. Sensors without Transmitters - Standard Application. Make a reading with a calibrated test instrument within 6 in. of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

c. Sensors with Transmitters - Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 in. of the site sensor. Verify that the sensor reading (via the permanent thermostat, gauge or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

Tolerances, Standard Applications

Sensor	Required Tolerance (+/-)		Sensor	Required Tolerance (+/-)
Outside air, space air, duct air temps	0.4F		Flow rates, air	10% of design
Watthour, voltage & amperage	1% of design		Flow rates, water Relative humidity Oxygen or CO_2 monitor CO monitor	4% of design 4% of design 0.1% pts 0.01 % pts
Pressures, air, water and gas	3% of design		Barometric pressure	0.1 in. of Hg

d. Valve and Damper Stroke Setup and Check EMS Readout: For all valve and damper actuator positions checked, verify the actual position against the BAS readout. Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

E. Execution of Construction Checklists and Startup:

1. Two (2) weeks prior to the scheduled start up, the Contractor shall coordinate startup and checkout with the Owner, A/E, OR, and CA. The execution and approval of the construction checklists, startup, and checkout shall be directed and performed by the Contractor, Subcontractor or Vendor. Signatures are required of the applicable Subcontractors for verification of completion of their work.

2. The Owner and facility personnel as necessary, shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, in which case a sampling strategy may be used.

3. For lower-level components of equipment, (e.g., sensors, controllers), the CA shall observe a sampling of the startup procedures.

4. The Contractors, Subcontractors and Vendors shall execute startup and provide the CA with a signed and dated copy of the completed startup and construction checklists.

5. Only individuals employed by the Contractor (Technicians, Engineers, Tradesmen, Vendors, etc.) who have direct knowledge and witnessed that a line item task on the construction checklist was actually performed shall check off that item. It is not acceptable for non-witnessing onsite supervisors to fill out these forms.

F. Deficiencies, Non-Conformance, and Approval of Checklists and Startup (Master Issues Log):

1. The Contractor shall ensure that the Subcontractors clearly list any outstanding items of the initial startup and construction checklist procedures that were not completed successfully, on an attached sheet. The form and any outstanding deficiencies shall be provided, to the CA within two (2) days of test completion.

2. The CA will review the report and issue either a non-compliance report or an approval form, to the Contractor. The installing Contractors or Vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, shall notify the CA as soon as outstanding items have been corrected, and resubmit an updated startup report with a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CA will recommend approval of the execution of the checklists and startup of each system.

3. Items left incomplete, which later cause deficiencies or delays during performance may result in backcharges to the Contractor.

3.5 FUNCTIONAL PERFORMANCE TESTING

A. Requirements: The functional performance testing shall demonstrate that each system is operating according to the documented design intent and contract documents. Functional

performance testing facilitates bringing the systems from a state of individual substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

B. Coordination and Scheduling: The Contractor shall provide sufficient notice, regarding their completion schedule for the construction checklists and startup of all equipment and systems to allow the performance testing to be scheduled. The CA shall oversee, witness, and document the performance all equipment and systems. The CA, in association with the Contractor/Subcontractors and Facility Staff, shall execute the tests. Performance testing shall be conducted after the construction checklists, and startup has been satisfactorily completed. The control system shall be sufficiently tested and approved by the CA before it is used to verify performance of other components or systems. The air balancing and water balancing shall be completed and approved before performance testing of air or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems shall be checked.

C. Development of Test Procedures: Before test procedures are finalized, the Contractor shall provide to the A/E and the CA all requested documentation and a current list of changes affecting equipment or systems, including an updated points list, program code, control sequences, testing parameters, supplemental instructions, and addenda. Using the testing parameters and requirements in the technical specifications, the CA shall update/develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Contractor/Subcontractor or vendor, as appropriate, shall provide assistance to the CA in developing the final procedures. Prior to finalization, the A/E shall review and concur with the test procedure.

D. Test Methods:

1. 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. The CA may substitute specified methods or require an additional method to be executed other than what was specified, with the approval of the A/E. The CA will determine which method is most appropriate for tests that do not have a specified method.

2. Simulated Conditions. Simulating conditions shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

3. Overridden Values. Overriding sensor values to simulate a condition, such as overriding the outside air temperature reading in a control system to be something other than ambient is acceptable.

4. Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overridden values.

5. Altering Sensors. Overriding sensor values and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable.

6. Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the test parameters, that the indirect readings through the control system represent actual conditions and responses.

7. Setup. Each functional performance test shall be performed under conditions that simulate actual conditions as closely as is practically possible. The Contractor/Subcontractor(s) assisting the CA in executing the test shall provide all necessary materials, system modifications, etc., to produce the necessary flows, pressures, temperatures, etc., necessary to execute the test according to the specified conditions. At completion of the test, the Contractor/ Subcontractor(s) shall return all affected equipment and systems to their approved operating settings.

E. Problem Solving: The burden of responsibility to solve, correct, and retest malfunctions/failures is with the Contractor, with the CA providing suggestions.

3.6 DOCUMENTATION, NON-CONFORMANCE, AND APPROVAL OF TESTS

A. Documentation: The CA shall witness and verify/pre-approve the documentation of the results of all performance tests. The CA shall complete all documentation for performance testing.

B. Non-Conformance:

1. Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form or on an attached sheet. If the correction is made immediately, the item does not need to be added to the issues log.

2. As tests progress and a deficiency is identified, the CA shall discuss the issue with the Commissioning Team and the Contractor.

a. When there is no dispute regarding the deficiency and the Contractor accepts responsibility to correct it:

1) The CA will document the deficiency and the Contractor's response and intentions. After the day's work, the CA will enter the item into the issues log. The Contractor 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 CA.

2) The Contractor shall reschedule the test; and the test is repeated. The issues log is amended by the CA.

b. If there is a dispute about a deficiency, regarding whether or not it is a deficiency:

1) The dispute shall be documented on the non-compliance form with the Contractor's response.

2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E.

3) The CA documents the resolution process in the issues log.

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

3. Cost for the CA to retest a functional performance test is borne by Contractor's.

4. The Contractor shall submit in writing to the CA at least as often as commissioning meetings are being scheduled, the status of each outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreement and proposed resolutions.

a. The CA retains the original non-conformance forms until the end of the project.

b. Retesting shall not be considered a justified reason for a claim of delay or for a time extension by the Contractor.

C. Failure Due to Manufacturer Defect: If 10% (or three (3), whichever is greater) of identical pieces of equipment fail to perform to the contract documents (mechanically or substantively) due to a manufacturing defect, not allowing it to meet its submitted performance specification, all identical units may be considered unacceptable. In such case, the Contractor shall provide the Owner with the following:

1. Within one (1) week of notification from the Owner, the Contractor or Manufacturer's Representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CA within two (2) weeks of the original notice.

2. Within two (2) weeks of the original notification, the Contractor or Manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc., and all proposed solutions. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

3. The A/E will determine whether a replacement of all identical units or a repair is acceptable.

4. Two (2) examples, where applicable, of the proposed solution shall be installed by the Contractor and the A/E shall be allowed to test the installations for up to one (1) week, upon which the A/E will decide whether to accept the solution.

5. Upon acceptance, the Contractor and/or Manufacturer shall replace or repair all identical items, at their expense. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts or material can be obtained.

D. Approval: The CA notes each satisfactorily demonstrated function on the test form. Final acceptance of the functional performance test by the Owner is made after review by the CA, following recommendations by the A/E.

3.7 DEFERRED TESTING

A. Unforeseen Deferred Tests: If any check or test cannot be completed due to the project completion level, weather conditions, or time of season, execution of checklists and functional performance testing may be delayed upon approval of the CA. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Contractors will not be due any additional compensation.

B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity through the Owner. Tests will be executed, documented by the CA and deficiencies should be corrected by the appropriate Contractor/Subcontractors with the CA witnessing. Any final adjustments to the O&M manuals and as-built's due to the testing shall be made by the Contractor.

3.8 COMMISSIONING RECORD

A. The CA is responsible to compile, organize and index the following commissioning data, for all commissioned equipment into labeled, indexed and tabbed, three-ring binders and deliver it to the Owner.

1. Commissioning Plan.

2. System reports including available design narratives and criteria including sequences. Each system shall contain the startup plan and report, approvals, corrections, construction checklists, completed performance tests, trending and analysis, training plan and recommended recommissioning schedule.

3. Complete issues log inclusive of all items and resolutions.

4. Final Commissioning Report including 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. For each piece of commissioned equipment, the report should contain the disposition of the Commissioning Authority regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:

a. Equipment meeting the equipment specifications.

b. Equipment installation.

c. Performance and efficiency.

d. Equipment documentation and design intent.

e. Operator training.

5. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific performance test, inspection, trend log, etc. where the deficiency is documented. The 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.

3.9 PRE-WARRANTY REVIEW

A. CA will conduct a pre-warranty review of the project approximately ten (10) months following final completion of the project. CA will provide to the Owner a list of remedial items that are required to be addressed by Contractors prior to warranty expiration. Contractors, at their cost, will address all identified items in their respective trades within thirty (30) day of notification. Upon completion of work, Contractor will notify Owner, Commissioning Authority, and Design Architect/Engineer in writing.

END OF SECTION