

Part 1 General

1.1 APPLICABILITY

- .1 The work in this section lays out the responsibilities and the work required of the:
 - .1 Contractor
 - .2 Mechanical subcontractor
 - .3 Electrical subcontractor
 - .4 Controls subcontractor
 - .5 Testing, Adjusting, and Balancing subcontractor
 - .6 Other contractors providing services under the requirements of this contract as may be noted in this or other related parts of the specifications

1.2 DESCRIPTION

- .1 Commissioning is a systematic process of ensuring that all building systems installed in accordance with the drawings and specifications, manufacturer's requirements and good industry practice. Commissioning also ensures that equipment operates and performs, in and of itself as well as in the system, as was intended by the designers in response to the The City's requirements. Finally commissioning ensures the The City has the documentation and training required to operate the equipment and systems in a safe, efficient and long lasting manner.
 - .1 During the construction phase, commissioning will include the following specific activities:
 - .1 Verify equipment is installed in accordance with the manufacturer's recommendations and industry accepted standards including review of completed manufacturers' start-up sheets, supplemented where required with commissioning installation verification checklists provided by the CxA. Contractor shall complete check sheets as required by the CxA
 - .2 Verify equipment is set-up, adjusted and balanced to perform as specified. This will include review of Testing, Adjusting, and Balancing (TAB) procedures, review of TAB reports and spot checking measurements on site. The TAB contractor shall cooperate with the CxA providing information requested and tools and manpower for spot checking measurements as required by the CxA.
 - .3 Functional Performance Testing (FPT) of mechanical and electrical equipment and systems to ensure proper, complete and efficient operation under the range of conditions they are expected to encounter. Contractors shall provide manpower, tools and other services as required by the CxA to perform the FPT
 - .4 CxA will review O&M documentation provided to the The City to ensure it is complete and acceptable for ongoing operation and maintenance of the equipment. The review shall be sent to the consultant for incorporation with his comments. The Contractors shall provide changes as required by the Engineer.
 - .5 The CxA will witness the The City's operating personnel training to verify it was adequate and complete to ensure they fully understand the requirements of operating and maintaining the equipment. Contractors shall ensure training meets the approval of the CxA and provide additional training if requested.
 - .2 Commissioning does not take away from, reduce responsibility of or in any way diminish the requirement for system designers and installing contractors to provide a complete, finished and fully functioning product.

1.3 COORDINATION

- .1 Commissioning Team. The following contractors will be required to participate in commissioning and to assist the commissioning team with verification, testing and documentation preparation:
 - .1 Contractor (GC or Contractor)
 - .2 Mechanical subcontractor (MC)
 - .3 Electrical subcontractor (EC)
 - .4 Testing, Adjusting and Balancing contractor (TAB)
 - .5 Controls subcontractor (CC)
 - .6 Contractors installing insulation, windows and doors, air barrier or other building shell components.
 - .7 Any other installing Subcontractors or suppliers of equipment.
- .2 Other members of the commissioning team include:
 - .1 Commissioning Agent (CxA)
 - .2 The City's Project Manager (PM)
 - .3 Designated representative of the The City's Operations and Maintenance personnel (O&M)
 - .4 Architect and Design Engineers - particularly the mechanical and electrical engineers (A/M/E)
- .2 Management: Contractors shall cooperate fully with the CxA who will be the The City's representative for commissioning during all commissioning activities. Contractors shall work together and with the other members of the commissioning team as required to fulfil their contracted responsibilities and meet the objectives of commissioning.
- .3 Scheduling: The GC/CM will work with the CxA to schedule the commissioning activities required of contractors and subcontractors. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

The CxA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. As construction progresses more detailed schedules may be developed by the GC/CM.

1.4 RELATED SECTIONS

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| .1 | Mechanical – General | Divisions 22 and 23 |
| .2 | Mechanical – Controls | Section 23 09 33 |
| .3 | Mechanical – Testing, Adjusting & Balancing | Section 23 05 93 |
| .4 | Electrical – General | Division 26 |
| .5 | Electrical – Lighting | Section 26 52 00 |

1.5 RESPONSIBILITIES

- .1 Mechanical Subcontractor:
 - .1 Attend initial commissioning coordination meeting.
 - .2 Provide a complete set of all submittals for mechanical equipment for the CxA
 - .3 Provide complete equipment and systems start-up including personnel and tools, as required for safe, proper and complete start-up of all mechanical equipment.

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- .4 Perform installation verification, start-up and complete required documentation as directed by CxA.
 - .5 Correct all deficiencies found during installation verification, start-up and TAB to ensure that all equipment and systems are fully functional and ready for functional performance testing.
 - .6 Prepare O&M manuals and supplementary information on all equipment as directed by CxA and assemble in binders tabbed and indexed. Supplementary information may include, but is not limited to, such items as power/control field wiring diagrams, equipment maintenance schedule, vendor and maintenance contact lists. Submit to CxA when requested.
 - .7 Prepare preliminary schedule for O&M manuals submission, The City training, pipe and duct system testing, flushing and cleaning, equipment start-up, and TAB for use by the CxA. Update schedule throughout the construction period.
 - .8 Notify CxA a minimum of two weeks in advance of equipment and system start-up and/or installation verification testing.
 - .9 Set-up and schedule vendors and contractors required to participate in the The City training sessions for all equipment and systems.
 - .10 Provide a complete set of as-built record drawings and schematics, include a copy to the CxA.
- .2 TAB Subcontractor(s)
- .1 Attend initial commissioning coordination meeting.
 - .2 Provide a preliminary TAB report showing that the system is complete and capable of being balanced. Provide an additional copy of the preliminary report labelled "For CxA".
 - .3 Attend TAB review meeting scheduled by the CxA. Be prepared to discuss procedures that shall be followed in TAB and findings of preliminary TAB.
 - .4 Submittal of final TAB report showing all flows, pressures, motor speeds, voltages and amperages etc., as required for a full and complete balancing report on all systems. Provide an additional copy of the TAB final report labelled "For CxA", and include as-built distribution systems schematics.
 - .5 Participate in verification of the TAB report, which includes of repeating selected measurement contained in the TAB report where required by the CxA for verification or diagnostic purposes.
- .3 Building Controls and Automation System Subcontractor(s)
- .1 Attend initial commissioning coordination meeting.
 - .2 Attend Sequence of Operation and Graphics review meeting scheduled by the CxA. Be prepared to discuss all sequences including all changes, and provide a schematic for each proposed graphic.
 - .3 Provide the following submittals to the CxA at time of FPT. (Note: The following shall be updated to as-built conditions).
 - .1 Hardware and software submittals and shop drawings.
 - .2 Narrative description of each control sequence for each piece of equipment or system controlled.
 - .3 Point-to-point and sensor calibration verification checklists
 - .4 As-built diagrams showing all control points, sensor locations, point names, actuators, controllers and, where necessary, points of access, superimposed on diagrams of the physical equipment.

- .5 Printout of panel layouts including all analog input, analog output, digital input, and digital output connections. Provide a separate list for each stand alone control unit.
- .6 Printout of final control programming algorithms, include current values of all parameters for each system point.
- .7 The City's operation and maintenance manuals.
- .4 Provide complete training to operating personnel on hardware, operation and programming, and the application program for the system.
- .5 Demonstrate system performance to CxA. including all modes of system operation. (e.g. normal, abnormal, emergency).
- .6 Provide control system technician to operate systems as required by and under the direction of the CxA during system verification and functional performance testing.
- .7 Provide support and coordination with TAB contractor on all interfaces between their scopes of work. Provide all devices, such as portable operators' terminals, for TAB use in completing TAB procedures.
- .8 Provide any trend logs as may be required by the CxA.
- .4 Electrical Subcontractor
 - .1 Attend commissioning meetings scheduled by the CxA.
 - .2 Provide a complete set of all submittals for electrical equipment to the CxA
 - .3 Correct all deficiencies found during Installation Verification Inspection (IVI), start-up, TAB and FPT to ensure all equipment and systems are fully functional and in complete and proper working order.
 - .4 Prepare O&M manuals and supplementary information on all equipment as directed by CxA and assemble in binders tabbed and indexed. Supplementary information may include, but is not limited to, such items as power/control field wiring diagrams, equipment maintenance schedule, vendor and maintenance contact lists. Submit to CxA when requested.
 - .5 Provide electrical system technicians to assist during system verification and functional performance testing as required by the CxA.
 - .6 Provide a complete set of as-built record drawings and schematics with a copy to the CxA.

1.6 EQUIPMENT/SYSTEMS TO BE COMMISSIONED

- .1 Systems to be commissioned under this part are primarily associated with HVAC for the building and central plant but do not include process or special purpose equipment such as:
 - .1 life safety systems such as fire alarm, sprinkler, fire pumps
 - .2 security systems such as card readers, automatic door locks, CC cameras
 - .3 Communication systems such as data, paging and telephone systems
 - .4 specialty equipment such as kitchen cooking and refrigeration equipment, medical gas, elevators, laboratory equipment, etc. but scope does include exhaust hoods and fans
 - .5 Plumbing piping systems such as drainage and storm water management but scope does include booster pumps, hot water generation, cistern pumping and control systems for these

- .2 All major mechanical equipment and their controls will be commissioned using a series of installation verification and functional checks. Equipment to be commissioned during the course of this project includes but is not limited to:
- .1 Building Automation System (Controls System)
 - .2 Domestic Electric Water Heater
 - .3 Split Type Air Conditioners
 - .4 Air Handling Units
 - .5 Heat/Energy Recovery Ventilators
 - .6 Pumps
 - .7 Exhaust Fans
 - .8 Unit Heaters, Cabinet Unit Heaters
 - .9 VAV Boxes
 - .10 Fan Coil Units (Water Cooled Condensing Unit)
 - .11 Lighting
 - .12 Heat Exchangers
 - .13 Piping Systems
 - .14 Ducting Systems
 - .15 VFDs

Other major equipment as may be included in construction but may have been left off of this list will also be required to be included in commissioning.

Part 2 PRODUCTS

2.1 TEST EQUIPMENT

- .1 All standard testing equipment required to perform start-up and installation verification and required functional performance testing shall be provided by the division contractor for the equipment being tested.
- .2 Special test equipment, tools or instruments required by the contract documents shall be provided for commissioning and shall be left on site.
- .3 All testing equipment shall have had a certified calibration, traceable to a national standard, performed within the past year. If not otherwise noted, temperature sensors and digital thermometers shall have an accuracy of $\pm 0.1^{\circ}\text{F}$, pressure sensors shall have an accuracy of $\pm 1.0\%$ for each range available on the instrument (not the full range of the meter). All equipment shall be re-calibrated when dropped or damaged.

Part 3 EXECUTION

3.1 MEETINGS

- .1 Commissioning Meetings: Soon after construction commences, the CxA will conduct an initial commissioning scoping meeting with the entire commissioning team in attendance. Commissioning requirements, procedures, responsibilities and schedule will be reviewed.

Other commissioning meetings will be conducted as required throughout construction. These meetings will cover coordination, deficiency resolution and planning issues with particular Contractors and Subs.

3.2 SUBMITTALS

- .1 Provide one (1) copy of all shop drawings marked "for CxA" to the CxA at the same time as provided to other designers for review, including all controls and shop drawings and narrative description of each control sequence for each piece of equipment or system controlled.
- .2 Contractor and subcontractor shall comply with specific requests for submittal documentation from the CxA in a timely fashion to ensure commissioning work continues as scheduled. At a minimum, the request will include the manufacturer's printed installation and start-up procedures, O&M data and manuals, final shop drawings, power and control field wiring drawings, sequences of operation, and results of required tests.
- .3 Final completion of the O&M manuals including all required submittals is the responsibility of the Contractor. The CxA will review and forward comments to the engineer of record for follow-up.
- .4 TAB subcontractor shall supply an extra copy of the preliminary and the final TAB report marked "for CxA" for review. The CxA will review and forward comments to the engineer of record for follow-up.
- .5 Contractor shall provide an extra set of O&M manuals, as built drawings and field power wiring diagrams to the CxA. The CxA will review and forward comments to the engineer of record for follow-up.

3.3 START-UP AND INSTALLATION VERIFICATION CHECKS

- .1 The installing Contractor or Sub-contractor shall be responsible for performing and documenting start-up based on manufacturer's requirements and/or good industry practice. They shall perform all required procedures and checks and document the results. Start-up documents as requested by the CxA shall be provided.
- .2 Controls and Sensor Point-to-Point Checks. Control system point-to-point checks and calibration checks for all sensors shall be included as part of installation verification. The results shall be documented and provided to CxA.
- .3 Execution of Start-up and Installation Verification (IV/S-U).
 - .1 IV/S-U checklists shall be developed and provided by CxA. Where appropriate manufacturers checklists and procedures shall be combined or accepted in lieu of CxAs checklists.
 - .2 The Contractor, sub-contractor, manufacturer's rep or supplier shall perform IV/S-U. They shall complete the checklist on each piece of equipment. IV/S-U shall be successfully completed prior to any FPT.
 - .3 At his sole discretion the CxA shall observe, recheck or verify the IV/S-U documentation of any or all equipment. The contractor shall cooperate with and provide support to the CxA as requested.
 - .4 Only individuals with direct knowledge of and who personally witnessed any IV/S-U shall sign off the checklists.
 - .5 It will be the responsibility of the contractor to remedy all deficiencies found. Retesting by the contractor may be required to demonstrate corrections have been made.
- .4 Deficiencies, Non-Conformance and Approval of IV/S-U Checklists.
 - .1 Dates for remedy of deficiencies shall be provided to the CxA with the initial IV/S-U documents.
 - .2 The CxA will work with all parties as required to affect proper corrective measures, correct and retest deficiencies or uncompleted items.
 - .3 Items left incomplete or not properly corrected, causing delays or multiple call-backs for retest may result in back-charges to the party at fault.

3.4 TESTING, ADJUSTING, AND BALANCING (TAB)

- .1 A preliminary TAB balancing shall be done prior to final balancing. System deficiencies requiring correction prior to final TAB shall be documented.
- .2 All deficiencies shall be corrected by the contractor prior to final balancing.
- .3 Participate in repeating selected measurement as required by the CxA for verification or diagnostic purposes.

3.5 FUNCTIONAL PERFORMANCE TESTING (FPT)

- .1 In general, functional performance testing is conducted after IV/S-U have been satisfactorily completed, the control system is fully operational, and TAB is complete.
- .2 The installing Contractor or Sub-contractor, under the direction of the CA, shall execute all FPT and shall maintain responsibility for all equipment tested.
- .3 In general, each system shall be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part-load, full-load). Proper responses to such modes and emergency conditions (e.g., power failure, freeze condition, no flow, equipment failure, etc.) shall be verified.
- .4 FPT verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone data loggers. The CxA will determine which method is most appropriate.
- .5 The CxA will schedule FPTs through the GC and affected Contractors and Subs.
- .6 Corrections of minor deficiencies identified during FPT may be made by the Contractor or Sub during the tests.
- .7 Where a deficiency cannot be corrected immediately, the Contractor or Sub shall provide a reasonable timeline for correction. The CxA shall document the deficiency and reschedule the FPT.
- .8 Where there is a dispute regarding whether a problem is a deficiency or who is responsible, the deficiency shall be documented and resolution attempted by parties in attendance. Final acceptance of proposed resolution lies with the The City or designated representative.
- .9 The burden of responsibility to solve and correct deficiencies lies with the A/M/E, manufacturers, vendors, GC, Contractors, and Subs. The CxA may recommend solutions to problems in consultation with these parties.
- .10 Cost of Retesting:
 - .1 If the Contractor or Sub is responsible for a deficiency then they shall carry the cost to rework the deficiency and complete the IV/S-U or FPT.
 - .2 The CxA will direct the first retesting of the equipment at no charge.
 - .3 If corrections of deficiencies have been reported to be successfully completed but are determined during testing to be faulty or otherwise incomplete, the time for the CxA to direct second or subsequent retests will be charged back.

3.6 TRAINING OF THE CITY PERSONNEL

- .1 The contractor supplying each piece of equipment shall be responsible for providing complete and satisfactory training on that piece of equipment. Training may be performed by the contractor, supplier, manufacturer or others as the contractor may decide best able to provide that training.

- .2 The City personnel shall be provided with completed O&M Manuals at least 1 week prior to training. In addition, up to five (5) copies of the related maintenance booklet and wiring as-builts shall be provided to The City personnel for the purpose of training.
- .3 The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed. The CxA shall be responsible for overseeing and approving the content and adequacy of training for all commissioned equipment.
- .4 Basic training for each piece of equipment shall include the following items at a minimum:
 - .1 General description of the system and its operation (Design Intent)
 - .2 Detailed itemization and identification of major components and access to same
 - .3 Detailed itemization and identification of operating controls and safeties including normal and abnormal sensor readings
 - .4 Review of the O&M manuals for identification of service requirements, procedures, wiring diagrams, parts identification, safety procedures, etc.
 - .5 Review of system drawings and schematics
 - .6 Review of control drawings and schematics
 - .7 Operational review for
 - .1 Start-up
 - .2 Normal operation
 - .3 Shut down
 - .4 Unoccupied operation
 - .5 Seasonal changeover
 - .6 Manual operation
 - .7 Controls set-up and programming
 - .8 Troubleshooting and alarms
 - .8 Interactions with other systems
 - .9 Adjustments and optimizing methods for energy conservation
 - .10 Health and safety issues
 - .11 Regular maintenance requirements including frequency, parts and equipment, and tools needed, replacement parts sources
 - .12 Special maintenance needs
 - .13 Tenant interaction issues
 - .14 Discussion of environmentally responsible system features
 - .15 Identification of contacts for service support and maintenance parts

3.7 DEFERRED TESTING

- .1 If any check or test cannot be completed due to weather conditions, the building structure, required occupancy condition or other deficiency, execution of IV/S-U and/or FPT may be delayed upon approval of the The City.

3.8 SYSTEMS MANUAL

- .1 The CxA shall provide a systems manual, a document containing detailed descriptions and technical information about start-up, operation and maintenance of equipment. This document will then be reviewed with the The City.

END OF SECTION