**PART 1 – GENERAL**

* 1. **SUMMARY**
1. Section Includes:

1. General requirements for Commissioning (Cx) of HVAC systems and equipment including installation, start-up, testing, documentation, and training according to the Construction Documents.

2. Standard procedures for the execution of commissioning work shall be in conformance with Division 01, Section 01 91 13: General Commissioning Requirements. Coordinate work with the Commissioning Services Provider (CxSP).

B. Related Requirements:

* 1. Division 01: General Requirements.
	2. Section 01 45 23: Testing and Inspection.
	3. Section 01 79 00: Maintenance and Operations Staff Demonstration and Training.
	4. Section 01 91 13: General Commissioning Requirements.
	5. Section 23 05 00: Common Work Results for HVAC.
	6. Section 23 25 00: HVAC Water Treatment.
	7. Section 23 30 00: Air Distribution.
	8. Section 23 38 13: Kitchen Ventilation System.
	9. Section 23 50 00: Central Heating Equipment.
	10. Section 23 64 16: Oil Lubricated Centrifugal Water Chillers.
	11. Section 23 64 23: Scroll Water Chillers.
	12. Section 23 64 28: Air-Cooled Rotary Screw Chillers.
	13. Section 23 65 00: Cooling Towers.
	14. Section 23 80 00: Heating, Ventilating and Air Conditioning Equipment.
	15. Section 23 90 00: Testing, Adjusting, and Balancing for HVAC.
	16. Section 26 05 00: Common Work Results for Electrical.
	17. Section 26 05 13: Basic Electrical Materials and Methods.
	18. Section 26 05 19: Low Voltage Wires (600 Volt AC).
	19. Section 26 05 26: Grounding and Bonding.
	20. Section 28 31 49: Carbon Monoxide Detection and Alarm Systems.
	21. Section 26 05 86: Motors and Drives.
	22. Section 26 08 00: Electrical Systems Commissioning.
	23. Section 26 29 13: Adjustable Frequency Drives.
	24. Project Commissioning Plan (CxP).
	25. **REFERENCES**

A. Applicable codes, standards, and references: inspections and tests shall be in accordance with the following applicable codes and standards:

* 1. InterNational Electrical Testing Association – NETA.
	2. National Electrical Manufacturers Association – NEMA.
	3. American Society for Testing and Materials – ASTM.
	4. Institute of Electrical and Electronics Engineers – IEEE.
	5. American National Standards Institute – ANSI.
	6. National Electrical Safety Code – NESC.
	7. California Building Code – CBC.
	8. California Electrical Code – CEC.
	9. California Mechanical Code – CMC.
	10. Insulated Cables Engineers Association – ICEA.
	11. Occupational Safety and Health Administration – OSHA.
	12. National Institute of Standards and Technology – NIST.
	13. National Fire Protection Association – NFPA.
	14. American Society of Heating and Air-Conditioning Engineers – ASHRAE

(The HVAC Commissioning Process, ASHRAE Guideline).

* 1. Associated Air Balance Council – AABC (National Standards for Total System Balance).
	2. **SUBMITTALS**
1. Submittal’s package shall include the following:
2. Commissioning required submittals in accordance with Division 01 Specification Sections.
3. Copy of the Architect’s reviewed and accepted submittals to the CxSP via the OAR.
4. List of team members who will represent the Contractor in the Pre-functional Equipment Checks (PEC) and Functional Performance Tests (FPT), at least six weeks prior to the start of Pre-functional Equipment Checks.
5. Detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, a copy of full details of Owner-contracted tests, full factory testing reports, if any, and Warranty information, including responsibilities of Owner to keep Warranty in force clearly defined.
6. Installation and checklist documentation shipped with equipment and field checklist forms to be used by factory or field technicians.
7. Detailed manufacturer’s recommended procedures and schedules for PECs, supplemented by Contractor’s specific procedures, and FPTs, at least four weeks prior to the start of PEC.
	1. **MEETINGS, SEQUENCING AND SCHEDULING**
	2. Meetings: Attend the Cx meetings as required under Section 01 91 13 and Cx Plan.

B. Sequencing and Scheduling: The work described in this Section shall begin only after work required in related Divisions 23 and 26 Sections has been successfully completed and tests, inspection reports, and Operation and Maintenance manuals required have been submitted and accepted. The start-up and PEC shall be completed and submitted to the Owner at least two weeks prior to beginning FPT.

* + - 1. Coordinate HVAC work with the work of other trades prior to scheduling of any Cx procedures.
			2. Coordinate the completion of HVAC testing, inspection, and calibration prior to start of Cx activities.
	1. **QUALITY CONTROL**
1. Comply with Division 01 quality control specifications.
2. Incorporate manufacturer's recommended Cx procedures for the systems and equipment to be commissioned under this Section.
3. Comply with Section 23 90 00: Testing, Adjusting, and Balancing for HVAC.
	1. **EQUIPMENT AND SYSTEMS TO BE COMMISIONED**
4. Split Systems.
5. Make Up Air Units, with gas fired heat and evaporative cooling.
6. Fan Coil Units.
7. Single Package Gas Heating Electric Cooling Units.
8. Variable Volume and Temperature System.
9. Exhaust Fans.
10. Ventilators.
11. Pumps.
12. Water Heaters, Gas and Electric.
13. Boilers.
14. Chillers.
15. Cooling Towers.
16. Air Handling Units.
17. Air Conditioning Units.

**PART 2 – PRODUCTS**

* 1. **TEST EQUIPMENT**
	2. Equipment to be utilized in the commissioning process shall meet the following requirements:
		+ 1. Provide test equipment as necessary for the testing of the equipment and systems to be commissioned.
			2. Provide testing equipment and accessories that are free of defects and certified for use.
			3. Provide testing equipment with current calibration labels as per NIST Standards.

4. Equipment shall be calibrated on the manufacturer’s recommended intervals with calibration tags affixed to the instrument. In the absence of calibration tags, calibration documentation shall be submitted to the CxSP at least thirty days prior to use; this documentation shall include description and serial number of instrument and calibration data and date.

5. Testing equipment shall be maintained in good operating condition for the duration of the project.

**PART 3 – EXECUTION**

* 1. **COMMISSIONING PROCESS REQUIREMENTS**
1. Work to be performed prior to commissioning:
2. Complete phases of the work so the system(s) can be started, tested, adjusted, balanced, and otherwise commissioned.
3. If modifications or corrections to the installed system(s) are required to bring the system(s) to acceptance levels due to Contractor’s incorrect installation or defective materials, such modifications shall be made at no additional cost to the Owner.
4. Normal start-up services required to bring each system into full operational state:
	1. Testing, motor rotation check, control sequences of operation, full and part load performance.
	2. Commissioning shall not start until each system is complete and start-up has been performed.
5. Pre-Commissioning responsibilities:
	* 1. Inspection, calibration and testing of the equipment required to commission the following systems:
			+ 1. HVAC System(s).
6. Commissioning Process Requirements:

1. Refer to Section 01 91 13: General Commissioning Requirements and related Sections for information on meetings, start-up plans, Pre-Functional and FPT, operations and maintenance data, training requirements, and other Cx activities.

* 1. **PREPARATION**
1. Provide certified HVAC technicians as required, with tools and equipment necessary to perform Cx activities specified.
2. Provide certified testing agency personnel and equipment factory representatives as require in the Cx plan and other related Sections.
3. Verify that work required in this Section and in Section 01 91 13 is complete prior to starting of FPT.
4. Verify that complete operational manuals have been reviewed and accepted by the CxSP as specified before starting FPT.
	1. **TESTING**
5. Testing procedures shall include the following minimum information:
	1. Test number.
	2. Equipment used for the test, with manufacturer and model number and date of last calibration.
	3. Date and time of the test.
	4. Indication of whether the record is for a first test or retest following correction of a problem or issue.
	5. Identification of the system, subsystem, assembly, or equipment.
	6. Conditions under which the test was conducted, including (as applicable); ambient conditions, set points, override conditions, status, and operating conditions that impact the results of the test.
	7. Systems and assemblies test results and performance and compliance with contract requirements.
	8. Issue number, if any, generated as the result of the test.
	9. Name(s) and signature(s) of witnesses and the person(s) performing the test.
6. Contractor shall participate and perform Cx related testing requirements as specified.
7. General Requirements for Mechanical, Controls, and Testing and Balance:
	1. Construction and Acceptance Phases:
		1. Provide assistance to CxSP in preparing FPT procedures specified. Sample test forms are included in the project Cx Plan.
		2. Develop full startup and initial checkout plan using manufacturer’s start-up procedures and Cx checklists for commissioned equipment. Submit to CxSP for review and approval prior to startup.
		3. During startup and initial checkout process, execute mechanical-related portions of PEC for the equipment and systems to be commissioned.
		4. Perform and clearly document completed startup and system operational checkout procedure. Providing four copies of the results to the Owner.
		5. Resolve any open punch list items before FPT. Air testing and balance shall be completed with discrepancies and problems remedied before FPT of respective air -related systems.
		6. Provide skilled technicians to execute starting of equipment and to execute PFT. Ensure that technicians are available and present during agreed upon schedules and for sufficient duration to complete necessary tests, adjustments, and solutions to identified problems.
		7. Maintain a log of events and issues of tests and related Cx activities. Submit handwritten reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests, and lists of completed tests as specified.
		8. Correct open issues and re-test as needed to prove compliance with system operational standards.
		9. Prepare Operation and Maintenance Manuals and provide training for the Owner maintenance personnel and end-users per Section 01 79 00.
		10. Coordinate with equipment manufacturers to determine specific requirements to maintain validity of Warranty and notify the Owner.
		11. Execute simulated seasonal FPT, witnessed by the Owner and the CxSP, as specified. Document results and perform corrections as needed for system acceptance and make necessary adjustments to Maintenance and Operations Manuals and Record Drawings.
	2. **SENSOR CALIBRATION**
8. Field-installed temperature, relative humidity, CO2, pressure sensors, pressure gages, and actuators (dampers and valves) shall be calibrated using the methods described below. Calibration procedures shall be documented during execution of the Start-up and the PEC. Alternate methods may be used, if approved by the CxSP.
9. Test instruments shall have had a NIST certified calibration within the last 12 months. Sensors installed in the unit at the factory with provided calibration certification need not be field calibrated.
10. Sensors:
	* 1. Verify that sensor locations are appropriate and away from causes of erratic operation.
		2. Verify that sensors with shielded cable are grounded only at one end.
		3. For sensor pairs that determine a temperature difference, make sure they are reading within 0.2 degrees F of each other.
		4. For sensor pairs that determine a pressure difference, make sure they are reading within 2 percent of each other.
		5. Calibration: Put the equipment in operation. Make a reading with a calibrated test instrument within six inches of the site sensor. Verify that the sensor reading (via the permanent thermostat or gage) is within the tolerance listed in the table below of the instrument-measured value. If not, calibrate or replace sensor.
		6. Tolerances:

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| Sensor | Required Tolerance (+/-) |
| AHU wet bulb or dew point | 2.0 degrees F |
| Outside air, space air, duct air temps | 0.4 degrees F |
| Watt-hour, voltage, and amperage | 1 percent of design |
| Pressures, air, water and gas | 3 percent of sensor range (inc. design value) |
| Flow rates, air  | 10 percent of sensor range (inc. design value) |
| Flow rates, natural gas | 5 percent of sensor range (inc. design value) |
| Relative humidity | 4 percent |
| CO2 monitor  | 100 ppm |
| Sound level  | 5 db - Type 1 meter (Per Calibrator Mfg.) |
| Domestic Hot Water Temperature | 1.5 degrees F |
| Domestic Hot Water Pressures Water and Gas | 3 percent of sensor range (inc. design value) |
| Flow Rates, Domestic Water | 4 percent of sensor range (inc. design value) |
| Flow Rates | 5 percent of sensor range (inc. design value) |

* 1. **ADJUSTING**

Perform work required to rectify installations not meeting contract requirements at no additional cost to the Owner.

Corrective work shall be completed in a timely manner to permit completion of the Cx process.

If systems’ Cx deadline, as defined in the Project Schedule, goes beyond the scheduled completion without resolution of the problem(s), the Owner reserves the right to obtain supplementary services or equipment to resolve the problem.

* 1. **TRAINING**
1. Provide training plan for systems to be commissioned as required in applicable Division 23 specification sections and Section 01 79 00.

END OF SECTION