SECTION 15995 - MECHANICAL COMMISSIONING

PART 1 - GENERAL

NOTE: This section applies to project that includes commissioning as part of the scope of work.

1.1 DESCRIPTION:

A. Purpose:

1. Verify operation and functional performance of central mechanical HVAC systems, controls & and electrical systems for compliance with "Design Intent", as defined by the Contract Documents.

2. Document Mechanical and Electrical system test and inspections.

3. Verify application of operation and maintenance manuals, as-build (record) documents, spare parts lighting, special tools, controls and other items as may be specified herein for support of Mechanical and Electrical systems and equipment.

4. Provide indirect support of the training of personnel for operation and maintenance of Mechanical and Electrical equipment and systems.

B. General:

1. Furnish labor and material to accomplish complete mechanical and electrical system commissioning as specified herein. Complete interim commissioning of HVAC systems during initial season operation.

C. Job Conditions: The commissioning contractor shall become familiar with the contract documents, all addenda, and change orders issued for this project prior to commencing the commissioning work.

1.2 QUALITY ASSURANCE:

A. Reference: ASHRAE Guideline 1P, "Guideline for Commissioning of HVAC System.

B. Qualifications: The "Commissioning Authority" shall be defined as a company or agency of experienced personnel, qualified to plan & carry out the overall commissioning progress. The Commissioning Authority shall submit for owner review, an outline of the organization's personnel qualification resources, commissioning, documentation process & commissioning plan specifically prepared for this project.

1.3 DOCUMENTATION:

A. The Commissioning Authority shall obtain the following:

1. Project plans and specification (contract documents), authorized revisions, shop drawings and submittals (approved, Test and Balance report, equipment start-up and certification reports, operation and maintenance manuals, etc.

2. Records of required code authority inspections, contractor test inspections, documentation sign-offs, etc.

1.4 SUBMITTALS:

A. Commissioning Authority will submit the name of the commissioning project manager approval prior to starting the commissioning process.

1. Commissioning Plan (describe extent and delivery schedule.)

2. Commissioning Outline Plan (describe extent of plan, expected duration of observations, personnel involved, schedule, etc.)

3. Tool List: provide a detailed list of the tools required for the commissioning process.

1.5 RESPONSIBILITIES OF OTHERS: Applicable specification sections outline trade responsibilities during the commissioning process.

A. General Contractor:

General Contractor shall verify completeness of the building envelope, perimeter and interior items, which effect proper operation, and control of HVAC equipment and systems.

The General Contractor will assure participation and cooperation of specialty contractors (Mechanical, TAB, building automation system, etc.) under his jurisdiction as required for the commissioning process.

B. Contractors Specialty:

Individual mechanical and electrical sub - will be responsible for providing labor, material, equipment, etc., required within the scope of this specialty to facilitate the commissioning process. The listed Sub-Contractor will perform tests and verification procedures required by the commissioning process when requested by the Commissioning Authority and directed by the General Contractor.

C. Owner/Operator:

1. Owner/Operator may schedule personnel to participate in commissioning process.

2. Owner/Operator will advise the Commissioning Authority regarding changes in building occupancy, usage, or functional requirements.

PART 2 - PRODUCTS

2.1 INSTRUMENTATION:

A. Instrumentation will be provided by agency performing prior tests. Instruments will be operated by individual agency requested by the Commissioning Authority, as specified elsewhere herein.

PART 3 - EXECUTION

3.1 GENERAL:

A. Commissioning Authority will participate in the final construction phase of the project to assure compliance with specific Commissioning requirements.

3.2 PROCEDURE:

A. Attend construction meeting and establish requirements for the Commissioning process throughout construction phase.

B. Prepare and submit to the owners representative (name) (time) after contract award, a Commissioning plan which shall outline:

1. Responsibility of each trade affected by Commissioning as required by appropriate section of this specification.

2. Requirement for documentation as listed elsewhere herein.

3. Requirements for documentation of tests and inspections required by code authorities.

4. Requirements for the Commissioning program during specified operational seasons part and full loads as further delineated in 3.03.

C. Periodically attend construction and coordination meetings.

3.3 MECHANICAL SYSTEMS COMMISSIONING:

A. Mechanical System Commissioning shall begin after HVAC equipment and systems, along with related equipment; systems, structures and areas are complete.

B. Verify TAB readings, such as:

1. Supply and return air CFM quantities.
2. Fan performance
3. Hydronic performances
4. Branch duct readings
5. Refrigeration side performance
6. Chiller performance
7. Cooling tower performance
8. Boiler performance

C. Verify calibration of thermostats and related controls, such as:

1. VAV boxes
2. Multizone-Zone damper settings and operators
3. Valve positions
4. Damper position

D. Verify readings of remote data and control systems, such as:

1. Temperature
2. Air flow
3. Damper positions
4. Water pressure
5. Water temperatures

E. Verify operation of system modes, such as economy cycle, smoke removal and in specific:

1. Damper and fan operation
2. Smoke detector response

3. Zone response

F. Verify that total HVAC system is performing to provide conditions as outlined in the contract documents, including seasonal, part and full load conditions.

COMMISSIONING CHECKLIST

The following commissioning checklists are provided to illustrate the minimum information, which should be included in the commissioning checklist final report.

COMMISSIONING CHECKLIST - CENTRIFUGAL CHILLER

1. PRIOR TO FUNCTIONAL PERFORMANCE TEST:

a. Chiller has been set in place and piped - hydrostatically leak tested.

b. Factory start-up and check out complete with report submitted.

c. Chiller safety and protection devices tested, report submitted.

d. The following check lists completed and submitted:

1) Chilled water/condenser water pumps.
2) Cooling tower.
3) Controls and instrumentation checklist.
4) Test and Balance Report submitted.
5) Chemical treatment report.

e. Personnel present during demonstration:

1) General Contractor, Mechanical, Electrical, and Controls Contractor.
2) Commissioning authority.
3) Owner's representative.

f. Functional Performance Test: Contractor shall demonstrate operation of chilled water system as per specifications including the following: Start building air handler to provide load for chiller. Activate controls system chiller start sequence as follows:

1) Time of day start-up program initiates chiller start.
2) Start condenser water pump, establish flow, and activate chiller proof of flow switch.
3) Start chilled water pump, establish flow, and activate chiller proof of flow switch.
4) Control system energizes chiller start sequence.
5) Chiller senses chilled water temperature above set point, chiller control system activates start.
6) Verify functioning of "soft start" sequence, record motor amperage as a time function.
7) Verify cooling tower controls function, refer to checklist.
8) Chiller load to be calculated by controls system, provide trend log of load imposed.
9) Shut-off air handler to remove load on chilled water system.
10) Verify chiller shut down sequence after load is removed.
11) Re-start air handler within 2 minutes of chiller shut down. Verify condenser and chilled water pump, cooling tower controls sequence.

2. Results:

a. The Commissioning Authority shall report results obtained in 3 above.

1) If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

b. Reports:

1) Submit reports of Functional Performance Test above to owner’s representative.

COMMISSIONING CHECKLIST - PUMPS

1. Prior to Functional Performance Test

a. Pumps in place, grouted, vibration isolation devices functional, pump alignment, and rotation verified.

b. Power available with motor protection, safeties, control system contractors, and interlocks functional.

c. Piping system pressure tested, cleaned, chemical water treatment complete and report submitted. Piping systems filled and chemically treated (where applicable).

d. Pressure and temperature gauges installed and functional.

e. Water balance complete with design maximum flow, pressures obtained, and report submitted

2. Personnel present during functional performance test:

a. General Contractor, Mechanical Contractor, Controls Contractor, Electrical Contractor.
b. Commissioning authority.
c. Owner's representative.

3. Functional performance test: Contractor shall demonstrate operation of pumps as per specification including the following:

a. Activate pump start using control system command.

b. Verify pressure drop across strainer, verify strainer is clean. Verify pump inlet/outlet pressure reading, compare to Test and Balance Report, pump design conditions, and pump manufacturer's performance data. Operate pump at shut-off, 50% and 100% flow. Plot test readings on pump curve. Verify specified flow is obtained.

c. Verify motor amperage each phase and voltage phase to phase and phase to ground.

d. Check and report unusual vibration, noise, etc.

4. Results:

a. The Commissioning Authority shall report results obtained in 3 above.

b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

a. Submit reports of functional performance test item 3 above to owner’s representative.

COMMISSIONING CHECKLIST - COOLING TOWER/CHEMICAL TREATMENT

1. Prior to Functional Performance Test:

    a. Cooling tower is in place, piped; motor and fan drive adjusted, make-up valve and water supply piped.

    b. Power is available with motor protection safeties and disconnect at tower operational. Controls systems, contractor's interlocks functional. Motor and fan rotation checked.

    c. Tower basin is filled, cleaned, and water treatment system functional with report from treatment contractor submitted.
    d. Water balance is complete with design flow verified and water distribution headers balanced.

    e. Fan lubricated and blade pitch adjusted.

2. Personnel present during demonstrations:

    a. General Contractor, Mechanical, Electrical, and Controls Contractor.
    b. Commissioning authority.
    c. Owner's representative.

3. Functional Performance Test: The Mechanical Contractor shall Functionally Performance Test the operation of the cooling tower as per specification and the following:

    a. Activate cooling tower fan start using control system command. This should first start condenser water pump, establish flow, and delay fan start for 30 seconds to equalize flow in distribution basin and sump. Start fan after times delay.

    b. After chiller start-up, control system should modulate bypass valve and two-speed fan motor to maintain 75^{o}F return water temperature to chiller. Observe and record functioning of bypass valve under varying loads.

    c. Verify interlock with chiller; cooling tower fan should operate concurrently when chiller is energized.

    d. Verify make-up water float valve is functioning. Activate chemical treatment feed valve; verify make-up of chemical treatment system, pump, and controls.

    e. Sample cooling tower water and test for suspended solids, record solids meter reading for each sample to verify accuracy.

    f. Record reading on tower make-up water supply meter, compare to chiller load summation of ton-hours. Make-up water use would be 2 gallons per ton hour. Report variance. Record amount of chemical used, forward to water treatment contractor for review and approval based upon amount of make-up water used.

4. Results:

    a. The Commissioning Authority shall report results obtained in 3 above.

    b. If specified equipment performance is not verified, Commission Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

    a. Submit reports of Functional Performance Test item 3 above to engineer.

COMMISSIONING CHECKLIST - HOT WATER BOILERS

1. Prior to functional performance test:

    a. Boiler has been set in place and piped - hydrostatically leak tested.
    b. Factory start-up and check out complete with report submitted.
    c. Boiler safety and protection devices tested, report submitted.

2. The following checklists completed and submitted:

    a. Boiler water.
    b. Primary and secondary water pumps.
    c. Controls and instrumentation checklist
    d. Test and Balance Report submitted.
    e. Chemical treatment report.
    f. Natural gas and oil delivery systems.
    g. Boiler flues.

3. Personnel present during demonstration:

    a. General Contractor, Mechanical, Electrical, and Controls Contractor.
    b. Commissioning authority.
    c. Owner's representative.

4. Functional Performance Test: Contractor shall demonstrate operation of hot water boiler system as per specifications including the following: Start building air handlers to provide load for boiler. Activate controls system boiler start sequence as follows:

    a. Time of day start-up program initiates boiler start.
    b. Start boiler water pump, establish flow, and activate boiler proof of flow switch.
    c. Start boiler internal circulation pump.
    d. Verify low water cutoff safety and water makeup supply.
    e. Verify operation of temperature and pressure gauges. Operate high-pressure limit control.
    f. Verify operation of water relief valves.
    g. Verify operation of temperature controls to operate burner.
    h. Verify burner operation on natural gas including a 4:1 turn down modulation and gas trans safety.
    i. Verify burner operation on #2 fuel oil including operation of integral fuel oil pump.
    j. Verify operation of forced draft blower and combustion air modulating damper.
    k. Inspect boiler control panel for operation of controls and indicating lights.
    l. Verify ignition timing for pre-combustion pure and post combustion purges and flame failure shut down.
    m. Verify chemical treatment report.
    n. Provide boiler stack analysis to verify full load and part load thermal efficiency.

5. Results:

    a. The (Commissioning Authority) shall report results obtained in 3 above.
    b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

6. Reports:

    a. Submit reports of Functional Performance Test above to Owner's representative.

COMMISSIONING CHECKLIST - VAV DEVICES AND DUCTWORK

1. Prior to Functional Performance Test:

    a. All VAV boxes are in place, ducted, connected to controls system, heating boxes connected to electrical circuits with local disconnects mounted.

    b. Ductwork complete, as-built shop drawings submitted, duct pressure and leakage test complete.

    c. Duct static pressure sensor installed, calibrated and transmitting 4-20 MA signal to fan speed controller. DDC controls system operational with input/output from each VAV box and thermostat verified, local controller functional and monitoring CRT functional.

    d. Smoke/fire dampers installed as required with access, verify status as to open/closed position.

    e. Test and balance operation is complete including each VAV box calibrated for maximum/minimum flow settings, low pressure duct and devices balanced at maximum flow conditions, heating VAV boxes fan speed setting/air flow adjusted.

2. Personnel present during demonstration:

    a. General Contractor and Mechanical, Controls and Electrical Contractor.
    b. Commissioning authority.
    c. Owner's representative.

3. Functional Performance Test: Contractor shall demonstrate operation of VAV boxes as per specifications including the following:

    a. Cooling/heating VAV boxes: With system as described above, perform all cooling only tests at noted. In addition, for space heating requirement demonstrate the following:

        1) VAV box response to room temperature set point adjustment at local controller and CRT. Changes to be 78^{o}F to 68^{o}F, 72^{o}F and 82^{o}F.

            a) Check damper maximum/minimum flow settings.

            b) Verify damper actuator response to control input changes and rate of response. Record room temperature change, rate of change and overshoot/undershoot of desired temperature.

    b. VAV box response to sensor call for heating via set point adjustment, local controller and CRT changes. Changes to be warm up from 55^{o}F to 68^{o}F, from 68^{o}F to 74^{o}F. Verify cooling damper closes to minimum position, fan energized to circulate air, and upon further drop in space temperature (T-stat adjustment acceptable), verify hot water reheat activation, deactivation, and shut off on loss of air flow. Loss of airflow to be demonstrated by interrupting interlock or manual air vane flow sensor adjustment. Record room temperature change, rate of change and overshoot/undershoot of set point temperature.

4. Results:

    a. The Commissioning Authority shall report results obtained in 3 above.

b. If specified equipment performance is not verified, the Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

6. Submit reports of Functional Performance Test item 3 above to the owner's representative.

COMMISSIONING CHECKLIST - AIR HANDLING UNITS

1. Prior to Functional Performance Test:

   a. Verify unit is properly installed, securely fastened to floor with vibration isolators, access doors are operable and sealed, dampers and casing undamaged, insulation, and drain pan and interior are not damaged. Check and verify condensate drainage is unobstructed.

   b. Verify power available to unit disconnect and control panel.

   c. Verify chilled water piping or DX piping (where applicable) is connected to cooling coils, pressure tested, cleaned, and chemical treatment performed with report submitted.

   d. Verify control valves and damper actuators are installed, control power is energized and valves/dampers operable.

   e. Verify variable speed supply fan controller is energized with control power source available (if applicable).

   f. Verify shipping blocks on supply fan isolation rails are removed, fan drive and motor adjusted, check rotation.

   g. Verify return fan drive and motor adjusted, check rotation.

   h. Verify construction start-up T & B filters removed and replaced with new filters. During testing, completely blanket filters with filter media to simulate 0.5 in W.C. pressure drop (1/2 dirty filters).

   i. Test and Balance Report submitted.

2. Personnel present during demonstration:

   a. General Contractor and Mechanical, Electrical, and Controls Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: Contractor shall verify operation of air handling unit (AHUS) as per specification including the following:

   a. Activate AHUS using control system command.

   b. The following sequence of control shall be verified:

      Start-up

      1) Minimum and economizer outside air damper closed.
      2) Return air damper open.
      3) Relief air damper closed.
      4) Low temperature cutout allows start of fan if temperature inside unit is above 45^{o}F.
      5) Multizone AHUS zone dampers motors are installed and operational.

c. Normal Day-time operation - ambient temperature above specified economizer changeover.

1) Minimum outside air damper open.
2) Economizer outside air damper closed.
3) Return air damper open.
4) Relief air damper closed.
5) Fan multizone controller receiving signal from temperature sensor.
6) Chilled water control valves modulate to maintain 55^{o}F leaving air temperature.

d. Economizer cycle outside air temperature less than specified economizer changeover.

1) Minimum outside air damper open
2) Economizer outside air damper modulated to maintain 60^{o}F supply air.
3) Relief air damper modulates to relief economizer supply air.
4) Chiller and chiller pumps/cooling tower and pumps off.
5) Fan multizone controller receiving signal from temperature sensor.

e. Nighttime shut down (where applicable).

1) Outside air dampers closed.
2) Return air damper open.
3) Relief air damper closed.
4) Ambient conditions below 45^{o}F, activate unit-heating coil to maintain 50^{o}F inside building.

f. Verify VAV fan inlet vain controller calibration and maintenance of duct static pressure 1.5 in w.c. 0.2 in during 20% to 100% of design air flow.

g. Verify chilled water coil control valves sequence to operate 1/3 coil valve to full open, then 2/3 coil valve to full open and the reverse sequence under varying load conditions.

h. Verify unit shut down during fire event initiated by smoke/heat sensors, or day room smoke purge activation.

i. Verify airflow balance, outside air/return air; during variable unit air flow conditions.

4. Results:

a. The Commissioning Authority shall report results obtained in 3 above.

b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

a. Submit reports of Functional Performance Test item 3 above to owner's representative.

COMMISSIONING CHECKLIST - BAS CONTROLS SYSTEM

1. Prior to Functional Performance Test:

a. All control devices are in place, operable, calibrated, and communicating with local control panels and operator interface terminal communicating with local control panels and operator interface terminal (CRT).

b. Test and verify power supplies, wiring, low voltage transformers, allowable voltage drops, and related interlocks are available and meet specifications. Continuity has been checked.

c. Verify that control software programs have been loaded, edited and operational.

d. Controlled devices, mechanical equipment, actuators, and sensors are complete and operable.

e. Interrupt building power supply for 30 minutes, re-energize, verify software packages and programming remained intact and operable after interruption.

2. Personnel present during demonstration:

a. General, Mechanical, Electrical, and Controls Contractor.
b. Commissioning authority.
c. Owner's representative.

3. Functional Performance Test: Contractor shall verify operation of the controls system as per specification and the following:

a. Sensing Element: Verify wall mounted sensing elements are located per plans, securely mounted on wall with protective cover. Furnish plans, securely mounted on wall with protective cover. Furnish calibrated digital thermometer 40-105^{o}F +0.5^{o}F accuracy to verify reporting temperature of each sensing element. At each sensing element compare temperature sensed vs. actual temperature. Query each sensing element from local control panel and CRT; allowable variance is 0.5^{o}F from digital thermometer.

b. Follow procedure described in item a) above for all temperature-sensing device.

c. VAV box controllers, refer to demonstration procedure in VAV section.

d. In each VAV control zone, reset set point from 72^{o}F to 60^{o}F, and then record time to achieve set point (as climatic conditions and internal loads permit).

e. Night setback (as climatic conditions allow): Verify heating VAV boxes operate to maintain 55^{o}F space temperature.

f. Morning warm-up cycle: Verify warm-up time, trend logging function, and reset of warm-up time at different ambient conditions, i.e. 50^{o}F ambient and 30^{o}F.

g. Air Handling Unit: Refer to demonstration procedure in applicable section. At CRT, reset leaving air temperature set point, log response of multizone AHU's zone control valves, space temperatures, VAV box reactions, and system flow in system.

h. Chiller/cooling tower/pumps: Log chiller load and leaving water temperature as a result of resetting chilled water set point from 45^{o}F to 50^{o}F.

i. For all controls Functional Performance Test, Prepare report in format as follows:

Binary points (per specified points list:

1) Verify	YES	NO
Command issued	___	___
Command accepted	___	___
Command executed	___	___
Controlled device responded	___	___

Feedback verified response ___ ___

Analog points (per specified points list)

2) Verify	INITIAL* YES	NO	FINAL* STATUS	STATUS
Command Issued	___	___	_____	_____
Command Accepted	___	___	_____	_____
Command Executed	___	___	_____	_____
Controlled device Responded	___	___	_____	_____
Feedback Verified Response	___	___	_____	_____

*Status/readings to be reported as follows:

Control Signal
Actual system effect: Air flow, temperature, pressure, etc.

For interlocked devices, positioners, multiple points of control for each command, list effect and response on all devices.

4. Results:

   a. The Commissioning Authority shall report results obtained in 3 above.

   b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-scheduled Functional Performance Test.

5. Reports: Submit reports of Functional Performance Test item 3 above to The Owner's Representative.

COMMISSIONING CHECKLIST - HOUSING CELL/DAY ROOM SMOKE PURGE

1. Prior to demonstration:

   a. Smoke removal fan place, with motorized fire/smoke damper functional.

   b. Emergency power with motor protection, safeties and disconnect at fan functional. Controls system, contactors, interlocks, and smoke detectors functional. Motor and fan rotation checked.

   c. Intake air louvers are set, motorized dampers installed and interlocked with fan dampers.

   d. Test and balance has been performed and report submitted.

2. Personnel present during demonstration:

   a. General, Mechanical, Electrical and Controls Contractor.
   b. Commissioning authority.
   c. Owner's representative.

3. Functional Performance Test: Contractor shall demonstrate operation of the smoke purge system as per specifications and the following:

   a. Perform test as directed by Owner's Representative or as required by code.

b. Verify fan energized as a result of detector activation, intake louvers open to provide purge air for exhaust fan.

c. Verify fan exhaust cfm, check if differential pressure exceeds 0.1 in w.c. Negative with adjacent spaces and outside.

4. Results:

a. The Commissioning Authority shall report results obtained in 3 above.

b. If specified equipment performance is not verified, Commissioning Authority shall report remedial action required and re-schedule Functional Performance Test.

5. Reports:

a. Submit reports of Functional Performance Test item 3 above to the Owner's Representative.

END OF SECTION 15995