SECTION 23 08 00 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the commissioning process for facilities. Commissioning is intended to ensure the quality and functionality of installed building systems and assemblies, optimize building system performance, ensure that owner and occupant requirements are met, and aid in the orderly transfer of systems to the university.

B. Commissioning is required on all projects. Utilization of outside resources will be decided on a project-by project basis with approval of the university Facilities Operations through the University Project Manager. If no outside resources are utilized, then the engineer will complete the commissioning of the project.

C. Systems to be commissioned should include LEED Energy and Atmosphere minimum of fundamental commissioning prerequisites and should consider LEED Enhanced Commissioning work with the University Project Manager and LEED rating for new building, addition or major renovation.

1.2 SYSTEM PERFORMANCE REQUIREMENTS

A. Commissioning Authority shall:
1. Coordinate and direct each step of the commissioning process, and recommend acceptance or non-acceptance to the university's representative.
2. Assist in clearly identifying problems encountered in testing the functional performance of the mechanical system and cooperatively assisting in the development of the solutions to those problems. These potential problems may involve mechanical design, mechanical installation, mechanical equipment, controls devices, controls installation, controls software, etc.
3. Coordinate directly with each sub contractor with respect to their responsibility and contractual obligations.
4. Obtain, assemble and submit commissioning documentation.
5. Attend periodic on-site commissioning activities.
6. Develop the commissioning plan and schedule.
7. Develop the commissioning checklists and functional performance test plans. If there is a conflict between the requirements of the engineer and those of the Commissioning Authority, and the conflict cannot be resolved, the requirements of the Engineer shall have precedence.
8. Coordinate the installation verification inspections.
9. Review the control documentation and interface with other systems.
10. Review the operation and maintenance information and as-built drawings provided by the various sub-contractors and vendors.
11. Note any inconsistencies or deficiencies in the system.
12. Enforce system compliance and recommend modifications to the system design that will correct or enhance the system performance.
13. Coordinate the university's representative for witnessing of the tests.
14. Be present during start-up activities to assist and witness the execution of start-up checks and procedures.
15. Monitor the performance of the Test, Adjust and Balance contractor.
16. Review the accuracy and calibration of any instrumentation utilized for the functional performance testing and point to point testing.
17. Direct the functional performance testing.
18. Track commissioning deficiencies until correction.
19. Prepare and submit the commissioning reports.
20. Provide an 8 hour training class for up to six maintenance personnel.
21. The Commissioning Authority shall include in the commissioning bid.

a. All required costs to identify the design and construction problems as they relate to the mechanical system functional performance and acceptance.
b. Assistance in the process of proposing solutions to mechanical system functional performance and acceptance problems.
c. Assistance in implementing the solution for a mechanical system functional performance and acceptance problem.

22. In the event that any one of the contractors or engineers are unwilling or unable to participate in the commissioning process and/or the resolution of problems identified in the commissioning process, that portion of the commissioning process shall be discontinued until such time that contractor/designer participation and problem resolution is resumed. The Commissioning Authority shall notify the university's representative in writing of:
    a. The portion of the commissioning process in question.
    b. The problem being encountered with the system.
    c. The problem being encountered with the contractor/designer.
    d. The approximate costs encountered in attempting to get cooperation and projected costs in completing that portion of the commissioning process.

B. Smoke Management System Commissioning Authority:
1. Inspect the following:
    a. Automatic dampers
    b. Fans
    c. Controls diagrams
    d. Marking & identification
2. Verify the following:
    a. Vestibules
    b. Fans
    c. Detection devices
    d. Dampers
    e. Inlets and Outlets
    f. Smoke barriers
    g. Standby power
    h. Control action & Priorities
    i. Controls
    j. Response time
3. Reports: Provide the following reports and forms:
    a. Verification plan
    b. Testing & Validation Forms
    c. Daily Log & Reports Forms
    d. Non-Compliance Forms

C. Design Engineer:
1. Provide the Basis of Design Document (BoD) for individual systems and for overall building systems integration to meet the OPR. The Basis of Design Document shall use narrative descriptions, lists, schematics or other means necessary to clarify the design team's approach to:
    a. Building energy conservation
    b. Achieving target sustainability ratings
    c. Optimization of system and equipment efficiency at partial loads
    d. Ventilation requirements
    e. Basis of selection for primary heat distribution/removal methods
    f. Building pressure control
    g. Standards and guidelines compliance
    h. Redundancy considerations
    i. Product selection

    And shall specify:
    j. Specific indoor/outdoor design conditions
    k. Key heat load calculation inputs

l. Equipment full load operating requirements
m. Other criteria relevant to OPR requirements

2. The design engineer shall be responsible for the observations and checklists for the Installation Verification as defined in Part 3 of this Section.
3. Additional calculation and investigation of design adjustments needs by the engineers as defined by the Commissioning Authority.
4. Participate in the resolution of potential design concerns as discovered during the commissioning process.

D. Contractor:
1. The contractor shall be responsible for the Pre-functional Testing, a start-up procedure performed prior to balancing as defined in Part 3 of this Section.
2. The contractor shall be responsible for providing any technical personnel required for physical operation, testing and simulation of control sequences for each piece of controlled equipment as required by the Commissioning Authority during the Functional Performance Testing. This shall include chiller service personnel, boiler service personnel, the temperature control engineering and technical start-up crew, mechanical contracting service personnel for miscellaneous equipment, balancing contractor personnel, fire alarm contractor personnel, lighting contractor personnel, security system contractor personnel, and electrical contractor personnel. .. To the extent possible, these personnel will be scheduled
3. Additional calibration and adjustment of the mechanical equipment included in each mechanical system for proper operation under actual operation as defined by the Commissioning Authority.
4. Additional testing, calibration, adjustments, tuning, and minor adjustments to the temperature controls system sequences for proper operation under actual operations defined by the Commissioning Authority.
5. Additional testing, calibration and adjustment of the mechanical water and airflow of each mechanical system for proper operation under actual operation as defined by the Commissioning Authority.

E. The University shall:
1. Develop the Owner's Project Requirements (OPR) document in the pre-design phase with the assistance of the Commissioning Authority, and input from the design team, the end-user, and the O&M representative(s). Input shall be obtained using accepted methods such as questionnaires, surveys, workshops, etc. The OPR shall serve as the basis for the Basis of Design Document developed by the design team. The sections of the OPR pertaining to mechanical systems should detail:
a. Minimum and maximum interior temperature requirements by space or room number.
b. Interior air quality and humidity requirements by space type.
c. Specific building or room pressurization requirements
d. Projected occupancy levels and usage schedules
e. Control system preferences or exclusions
f. HVAC systems and equipment preferences or exclusions
g. Specific standards compliance requirements (ie. ASHRAE, JCAHO, NFPA, etc.)
h. Mechanical system requirements with respect to performance, compatibility, interoperability, redundancy, flexibility, or expandability
2. Appoint and schedule the university's representatives to participate in commissioning process.
3. Advise Commissioning Authority regarding any changes in the Owner's Project Requirements (OPR), such as building occupancy, usage, or functional requirements.

1.3 DEFINITIONS

A. Definition of Terms:
1. OPR (Owner's Project Requirements): a document that details the functional requirements of a project and the expectations of how it will be used and operated. These include project oals, verifiable and quantitative performance criteria, cost considerations, benchmarks, success criteria, and supporting information. This document is used as a basis for project design, commissioning

activities, and acceptance criteria. The OPR should be a living, up-to-date document that reflects any changes made or approved by the owner throughout the design and construction phases.

2. Basis of Design (BoD) Document: A document developed by the architect/engineer in the design phase based on the Owner's Project Requirements (OPR). The BoD describes the technical approach planned for the project as well as the design parameters to be used. The BoD translates OPR requirements into specific building components, systems, and control strategies and explains the justification for their selection. This document allows for necessary changes or modifications to take place in the design phase, and establishes requirements for the testing phase of project commissioning.
3. Installation Verification: This initial portion of the commissioning process includes observations and punch-list recorded and performed by the Engineer to ensure that all equipment is installed in accordance with the specifications and drawings. The Commissioning Authority shall overview this process.
4. Pre-functional Testing: This portion of the commissioning process involves primarily the test and balance and startup personnel to ensure that individual pieces of equipment are capable of performing in accordance with the specifications, drawings, and manufacturer's requirements. This is documented with a pre-functional checklist provided and completed by the contractor. The Commissioning Authority shall overview this testing.
5. Functional Performance testing: This portion of the commissioning process involves dynamic tests that ensure all mechanical systems function in accordance with design intent as defined in the BoD. The tests are dynamic and on-line and test the systems through all possible modes of operation.
6. Calibration: To check or adjust the graduation of a quantitative measuring instrument against a known standard.
7. Adjustment: To change the speed, flow, position, signal, or level of any piece of mechanical equipment.
8. Tuning: To adjust for maximum performance.
9. Minor Adjustment: To add, subtract, or change various parameters included on the operation of logic of a mechanical system or systems in order to improve or optimize operation performance. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major adjustment.
10. Major Adjustment: To fully change the specified operation logic of a mechanical system or systems. This refers only to the specified performance logic. Difficulties encountered in accomplishing a minor adjustment shall not be used to define a minor versus a major.
11. System Component or System Element: A single piece of mechanical equipment such as a pump, fan, chiller, boiler, coil, etc. that when combined together through piping or ductwork will comprise a "System".
12. System: A combination of system components that allow the manufacturer or distribution of conditioned air or water from one location to another.
13. The commissioning process is a joint team effort to ensure that all mechanical equipment, controls, and systems function together properly to meet the design intent of the Engineer and to document system performance parameters for fine-tuning of control sequences and operation procedures.
14. 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. Testing and balancing, controls and training are addressed in other sections of the Specifications.
15. The commissioning described herein, in not intended to supersede or replace the normal system startup by the contracting team, observations by the design team or balancing by the test and balance contractor.
16. Commissioning Process: In as much as possible, the commissioning process shall occur during the construction of the project for all portions of the mechanical systems that are scheduled to be complete at the opening day. This is intended to:
    a. Reduce as much as possible any duplication of work or testing for the contractor.
    b. Identify and solve any potential mechanical system design or construction problems as they relate to functional performance, prior to opening day.

17. The work included in the commissioning process involves a complete and thorough evaluation of the operation and performance of all components, systems, and sub-systems. Evaluate the following equipment and systems:
    a. Hydronic distribution systems.
    b. Air handling and air distribution systems.
    c. Domestic hot water systems.
    d. Variable frequency drives.
    e. Fire protection and suppression systems.
    f. Exterior switches and transformers.
    g. Electrical unit sub stations, switch gear, distribution transformers, distribution panelboards, and branch panelboards.
    h. Lighting systems.
    i. Motor control centers.
    j. Stand-by power systems.
    k. Building automation systems, hardware, software, and documentation.
    l. UPS systems.
    m. Glazing.
    n. Insulation.
    o. Indoor air quality.
    p. Building and special room pressurization.
    q. Computer room air conditioning systems.
    r. Fume hoods and special exhaust systems.
    s. Security systems.
    t. Fire alarm systems.
    u. Lightning Protection systems.
    v. Energy metering:
        1) Steam
        2) Chilled water
        3) Electric
    y. Building Envelope

B. Commissioning Team:
    1. The commissioning team shall be made up of the:
        a. Commissioning Authority
        b. Representative of the University
        c. Design Engineer
        d. Design Architect
        e. Construction Trades (specialty contractors)
    2. The trades represented on the commissioning team will include:
        a. General Contractor
        b. Mechanical Contractor
        c. Electrical Contractor
        d. Building Automation System Contractor
        e. Fire Alarm System Contractor
        f. Test, Adjust and Balancing
    3. The lead tradesman for each trade who will actually perform or supervise the commissioning work is to be designated as the representative to the commissioning team.
    4. Responsibility for various steps of the commissioning process will be divided among the members of the commissioning team, as described in this section.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Commissioning Process:
   1. Meetings:
      a. Scope Meeting: Early in the construction process, a commissioning scope meeting involving all members of the commissioning team shall be held at a time and place designated by the University Project Manager. The purpose of the meeting will be to familiarize all parties with the requirements of the commissioning process, and to ensure that the responsibilities of each party are clearly understood.
      b. Progress Meetings: During the course of the project, the Commissioning Authority shall conduct monthly commissioning meetings during the initial 75% of the project. During the final 25% of the project construction, the Commissioning Authority shall conduct weekly meetings.
   2. Reports:
      a. General:
         1) The Commissioning Authority shall record and maintain detailed testing data. The data record shall be comprehensive and concise.
         2) All data must be recorded as soon as possible during the course of testing,
         3) All documentation shall have the date, time, and names of persons participating in the inspection and testing.
         4) All test instruments shall be documented for valid calibration.
         5) The engineer and Commissioning Authority must approve the recording work sheets, inspection checklists, and performance testing plans. Approval must occur prior to the start of Functional Performance Testing.
      b. Daily Commissioning Report Logs:
         1) The Commissioning Authority shall provide daily report logs to be included in the final report.
         2) The daily logs shall record the Commissioning Authority personnel and event summaries of meetings, conversations, tests, failures, solutions, procedures and successes.
      c. Functional Performance Test Plans, Tables and Checklist:
         1) The Commissioning Authority shall prepare detailed test plans with associated checklists to organize and document the Functional Performance Testing.
         2) A separate test plan is required for each device or control sequence.
         3) A separate checklist is required for each of the equipment/systems.
         4) Provide testing tables for large quantities of repetitive test events such as outside air volumes, VAV box close-offs, valves, etc.
      d. Final Report:
         1) The Commissioning Agent shall prepare and submit to the university's representative a final report after completion of the commissioning.
         2) The report shall verify performance of HVAC equipment and systems.
         3) Documentation any field modifications to the testing process and why these modifications were made.
         4) The organizations of the final mechanical systems commissioning report shall be as follows:
            a) Executive Summary of each mechanical system and problems encountered and resolved.
            b) System Overview summarizing the system design.
            c) Commissioning Plan.
            d) Post Commissioned Controls Sequences and Points Lists.
            e) Prefunctional Testing Checklists.
            f) Functional Testing Procedures and Results.
            g) Smoke Control Testing Scenarios and Results.
            h) Appendix of letters, memo and notes occurring during the commissioning process.
         5) Final report in a PDF format with searchable text.

3.2 TESTING, CLEANING AND CERTIFICATION

A. General Requirements:
   1. All systems and system components shall be tested in presence of Commissioning Authority (and the engineer, if desired by the engineer) to demonstrate compliance with specified requirements. To minimize the time of commissioning, contracting and engineering team members, testing shall be done in seasonal single blocks of time insofar as possible.
   2. The contractor shall notify the Commissioning Authority fourteen (14) days prior to scheduled Functional Performance Tests, of the scheduled completion date of the Installation Verification and Pre-functional Testing.
   3. All testing shall be conducted under specified design operating conditions as approved by Commissioning Authority and engineer.
   4. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each subsystem, followed by entire system, followed by any inter-ties to other major systems.
   5. All special testing materials and equipment shall be provided by contractor. This includes, but is not limited to balancing readout and adjustment tools.
   6. Provide one copy of all test reports and records to Commissioning Authority.

B. Procedure and Test Documentation:
   1. Within sixty (60) days prior to startup of the mechanical system, the Commissioning Authority shall prepare and submit to the university's representative and engineer for review, descriptions of the test procedures which the contractor will perform to demonstrate conformance of completed mechanical systems to the plans and specifications.
   2. The decision of the Commissioning Authority and engineer upon acceptability of test procedures shall be final. In the event of an unresolved conflict between the Commissioning Authority and engineer, the engineer's decision shall have precedence. However, in no case shall such decision excuse the contractor from fulfilling the requirements of commissioning as described in this section.

C. Installation Verification Recommendations:
   1. All systems and system components shall be checked and verified that they have been installed according to the drawings and specifications, and that all connections have been made correctly.
   2. Each system of interactive system components shall be observed and verified that it is ready to function as specified.
   3. Verification of complete and proper installation shall be completed prior to starting Component Performance Tests.
   4. The Installation Verification shall be documented in a checklist format for each system/piece of equipment. Each checklist shall be dated and initialed by the engineer, mandatory.

D. Pre-functional Testing Requirements:
   1. All system components shall be checked to verify that they have been installed properly and that all connections have been made correctly. Verify that each piece of equipment or system has been checked for proper lubrication, drive rotation, belt tension, calibration, control sequence or other conditions which may cause damage.
   2. Verify that test, meter readings and specific electrical characteristics agree with those required by equipment or system manufacturer.
   3. All discrete elements and sub-systems of system components shall be adjusted and shall be checked for proper operation. Verify wiring and support components for equipment are complete and tested.
   4. The Pre-functional Tests shall be documented in a checklist format for each system and each piece of equipment. Each checklist shall be dated and initialed by the contractor, mandatory.

E. Functional Performance Testing Requirements:
   1. The Functional Performance Testing portion of the commissioning process shall begin after the installation of the HVAC equipment and systems, along with related equipment, systems, structures, and areas are complete.

2. A Functional Performance Test shall be performed on each complete system. Each function shall be demonstrated to satisfaction of the Commissioning Authority on a paragraph-by-paragraph basis of the written test procedure, developed to demonstrate conformance to requirements of contract specifications and the Basis of Design Document.
3. Each functional Performance Test shall be witnessed and signed off by the Commissioning Authority and contractor (and the university's representative and engineer if requested) upon satisfactory completion.
4. The Functional Performance Testing Program shall be conducted in accordance with prior approved procedures and shall be documented as required hereinafter.
5. The Commissioning Authority shall notify the the university's representative, the contracting team, the architect, and the engineer at least two weeks prior to date of scheduled Functional Performance Tests. Schedule each of the seasonal Functional Performance Test periods over a single block of days. The schedule seasonal Functional Performance Tests shall be based on the construction completion schedule. Further communication to the university representative, architect or engineer concerning the Functional Performance Testing schedule and changes to that schedule due to construction delays or coordination conf1icts shall not be required unless the noted parties have expressed an interest in writing in attending the testing.
6. Mechanical System Tasks: Verify that the total HVAC mechanical system is performing to provide conditions all possible modes of operation as outlined in the Basis of Design Document (provided by the engineer). The Functional Performance Testing procedures shall statistically represent all operating characteristics of all mechanical equipment and systems, including:
    a. Air handling and ventilation systems operation including exhaust fans, heat pumps, and fancoils.
    b. Chilled water system operation including chillers, pumps and controls.
    c. Condenser water system operation including cooling towers, pumps and controls.
    d. Heating water or steam system operation including boilers, pumps and controls.
    e. Ventilation systems operation including air handling systems, exhaust fans, supply fans, makeup air systems and controls.
    f. Terminal unit operation such as variable air boxes, fancoils, and heat pumps.
    g. Pressurization system operation.
7. Building Automation System Tasks: Verify that the total building automation system control system is performing to provide conditions through all possible modes of operation as outlined in the Basis of Design Document (provided by the engineer). The Functional Performance Testing procedures shall address all operating characteristics of a statistical representation of control system equipment, sequences, and instrumentation calibration. Include a point-by-point check to verify connectivity and control.
8. Test and Balance (TAB) Verification Tasks: Verify TAB readings for the approximate quantities of the following:
    a. 50% of Fan flows.
    b. 50% of Pump flows.
    c. 50% of Outside air volumes.
    d. 50% of Equipment pressure drops.
    e. 10% of the Supply (maximum and minimum primary air) return and exhaust diffusers, registers, and grilles.
    f. 10% of Hydronic flows.
    g. 10% of Balancing valve/damper settings.
    h. 10% of VAV box setups.
    i. 10% of Coil pressure drops
    j. If more than one-fifth of these readings differ from the documented TAB reading by more than 15 percent, then the TAB for the failed system shall be repeated in entirety.

3.3 COMMISSIONING (DEMONSTRATION)

A. The Commissioning Authority shall conduct a customized 8 hour training class for the university's engineering personnel in problem solving techniques with respect to the commissioned installation. This Commissioning Authority training does not reduce or exclude the training specified in other specification

sections, although portions of other specification sections, although portions of other specified training may be included as a part of the Commissioning Authority training. This problem solving class shall focus on the following:

1. Present the mechanical system design as a whole, integrated unit.
2. Point out the unique qualities of the installed mechanical system.
3. Provide insights into how to solve system-wide, multi-faceted problems.
4. Identify a variety of resources available to assist with problem solving.
5. The problem solving class is not intended teach day to day maintenance of parts and/or systems, establish emergency procedures, or "quick fix" problem solving approaches.

END OF SECTION 23 08 00