

SECTION 019113 – GENERAL COMMISSIONING REQUIREMENTS

PART 1 - GENERAL

1.1 SUMMARY

- A. Related Documents:
  - 1. Drawings and general provisions of the Subcontract apply to this Section.
  - 2. Review these documents for coordination with additional requirements and information that apply to work under this Section.
- B. It is of primary concern that all systems and assemblies in the project perform in accordance with the design intent and the University's operational needs. The process of assuring that such performance is achieved is referred to as "commissioning."
- C. Commissioning requires cooperation and direct involvement by all parties throughout the construction process. Successful commissioning requires that installation of all building systems and assemblies not only comply with contract requirements but also that it is achieved early enough in the construction phase to provide full operational check-out, testing and adjustments prior to Substantial Completion. In addition to fulfilling scheduling and planning requirements, the Trade Subcontractors are further responsible for documenting the equipment and system installation and operational verification for all systems and assemblies.
- D. The CMGC and Trade Subcontractors are solely responsible for the commissioning responsibilities given in the Specifications. If the CMGC elects to outsource commissioning responsibilities, the University must approve the agent via review of résumé and references.
- E. This Section includes a description of the commissioning process to be used for this Project and applies to all commissioned systems and assemblies.
- F. Overall Quality Assurance/Quality Control (QA/QC): Quality assurance and quality control on this Project shall be accomplished by the following, as specified. Not all elements are monitored by the commissioning process.
  - 1. Submittal reviews of Shop Drawings and material descriptions and certifications.
  - 2. Qualifications and approvals of certain specified sub-tier Contractors and testing agencies or laboratories.
  - 3. Inspection, testing and certifications by agencies provided by the University, including on-site and laboratory testing.
  - 4. Inspection, testing and certifications by agencies provided by the Trade Subcontractors, including on-site and laboratory testing.
  - 5. Inspection and testing by regulatory agencies.
  - 6. CMGC and Trade Subcontractor and University checks, inspections, tests and certifications.
  - 7. Mock-ups and evaluations.
  - 8. Commissioning: Commissioning enhances installation and setup and verifies the functional performance of the more dynamic systems through observation and testing as specified in this Section. Commissioning also may cover the QA/QC of certain static building elements or assemblies. Some QA/QC activities will be overseen by the commissioning process, while other QA/QC activities will be overseen by the CMGC, the Architect or University. Generally, the QA/QC activities that have traditionally been conducted in the past remain outside the formal commissioning umbrella, such as concrete testing, inspection of static building elements, and regulatory or code inspections. However, compiling the documentation of some of these traditional activities may be within the commissioning scope, as specified herein.
- G. Commissioning Process Overview: The following narrative provides a brief overview of the typical commissioning tasks during construction and the general order in which they occur.
  - 1. Commissioning during construction begins with a planning meeting followed by a kick-off meeting conducted by the Commissioning Authority where the commissioning process is planned and reviewed with the commissioning team members.
  - 2. Additional meetings will be required throughout construction, scheduled by the PM for the Commissioning Authority with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.

3. Equipment and assembly documentation is submitted to the University and their Commissioning Authority during normal submittals, including detailed start-up procedures and early copies of Operation and Maintenance (O&M) data, upon receipt of equipment to be installed on the project.
  4. The Trade Subcontractor develops start-up plans for selected equipment with review by the Commissioning Authority. The Commissioning Authority reviews the Trade Subcontractor developed construction checklists that are completed by the Trade Subcontractor during the start-up process. Responsibilities among parties are summarily listed in Supplement 3 to this section.
  5. In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with construction checklists being completed before testing.
  6. The Trade Subcontractor(s), under the direction of the Subcontractor's designated Commissioning Coordinator in accordance with the OEM equipment manual /system design that they installed as part of the project, execute and document the construction checklists and perform start-up and initial checkout.
  7. The Commissioning Authority documents that the checklists and start-up were completed through spot witnessing and review Trade Subcontractor's completed checklists and startup reports. Daily written/photo copy updates will be provided for commissioning status to the Commissioning Authority and University by the General Contractor and or their designated Commissioning Coordinator of their subcontractor(s). The documents shall be signed by the representative installing Trade Subcontractor (equipment start-up (OEM) and or Controls contractor (program point to point checklist) and submitted to the Commissioning Authority and University prior to functional performance testing.
  8. The General Contractor and/or their designated Commissioning Coordinator will report in the daily commissioning meetings per the schedule of all commissioning steps for all systems as part of the project. The General Contractor and or their designated Commissioning Coordinator will provide for in advance of the meetings in direction to their subcontractors for solutions and resolutions to late material deliveries, service vendor coordination, equipment replacement/ repairs for non-compliance and/or failures, etc. to maintain schedule of commissioning.
  9. The Subcontractor and or their designated Commissioning Coordinator will provide a detailed schedule within the Master Construction Schedule that includes all systems, required tasks/activities inclusive of necessary permits, work tasks, safety compliance steps, etc., by the mid-point of construction to the University and the Commissioning Authority (examples provided upon request). All University and Commissioning Authority comments and concerns will be addressed by the General Contractor and the General Contractor will be wholly responsible for all discrepancies, missed items, etc. and shall address and rectify them immediately at their expense.
  10. The Commissioning Authority performs periodic construction observation.
  11. The Commissioning Authority develops specific written equipment, system and assembly test procedures for all commissioned equipment. The procedures will include the expected/desired results.
  12. The test procedures are executed by the Trade Subcontractor, under the direction of the General Contractor and or designated Commissioning Coordinator in accordance with and documented by the Commissioning Authority for most equipment. Selected testing is directed and documented by the Trade Subcontractor (see Supplement 3 to this Section).
  13. Items of non-compliance in material, installation or setup are corrected by the Trade Subcontractor and the system is re-tested.
  14. The Commissioning Authority reviews the O&M manuals for clarity, accessibility and completeness that are specific to the equipment installed as part of the project.
  15. The Commissioning Authority reviews, pre-approves and coordinates the training provided by the Trade Subcontractor and verifies that is was completed.
  16. Commissioning shall be completed before Substantial Completion inclusive of 7/24 hour test(s), except for trend log monitoring, seasonal testing, near-warranty end activities, verification of later controls system training sessions, and review of final red-line drawings.
  17. Opposite season or deferred testing and near-warranty-end activities are conducted, as specified.
- H. Design phase reviews, not commissioning during construction, ensure that any given feature qualifies for a Leadership in Energy and Environmental Design (LEED) credit. Gathering LEED required documentation is not part of the commissioning scope of this Project, other than for the commissioning credit itself. All required documentation and procedures to comply with LEED Energy and Atmosphere commissioning prerequisite and the additional point are included in the commissioning scope.
- I. LEED requires that all features in the Water Efficiency and in the Energy and Atmosphere and most of the Indoor Environmental Quality areas are appropriately commissioned. The following equipment, systems, assemblies and features will be commissioned utilizing the traditional construction phase commissioning process that includes submittal review, construction checks, testing, observation, and training and documentation verification. All general references to equipment in this document refer only to equipment that

is to be commissioned. The responsibility for developing and reviewing forms, overseeing, documenting and witnessing execution and reviewing reports of checks and tests is distributed among constructors, designers and University parties and differs for different equipment types. The Check and Testing Responsibility Table (Supplement 3) included as a supplement to this Section lists these responsibilities.

1. HVAC and mechanical system and all integral equipment controls. All HVAC systems shall be commissioned, including, but not limited to:
    - a. Chilled water system (chiller, cooling tower, filtration system, chemical treatment, piping, pumps)
    - b. Heating water system (boilers, piping, pumps)
    - c. Air handlers
    - d. Hydronic piping (including air separators and expansion tanks)
    - e. Ductwork
    - f. Thermal comfort, temperature and humidity control
    - g. Variable speed drives
    - h. Air terminal boxes
    - i. Fan coil units
    - j. Restroom exhaust system
    - k. Facilities Monitoring and Control System
    - l. TAB work including 7/24 hr test(s)
    - m. HVAC and envelope differential pressure relationships
    - n. Fire protection system
  2. Electrical Systems:
    - a. Scheduled lighting controls
    - b. Lighting occupancy sensors Emergency egress lighting
    - c. Emergency power generator system. Load bank and ATS
    - d. Fire alarm system
    - e. Power and energy meters
  3. Laboratory and Clean Room
    - a. Cleanroom makeup air units
    - b. Cleanroom fan filter units
    - c. Cleanroom certification
    - d. Fume hoods and snorkel exhaust
    - e. Hood and process exhaust systems
    - f. Laboratory pressure and temperature control
    - g. Biological safety cabinets
    - h. Safety cabinets
    - i. Cold rooms
    - j. TAB work
  4. Process Mechanical
    - a. Treated Water System
    - b. Vacuum System
    - c. Compressed Air Systems
    - d. Bio-waste sterilization
    - e. Biomedical prep and glass cleaning
    - f. Pure water systems
    - g. Process gas systems
    - h. Process and M&P metering
- J. The following static elements and features will be commissioned utilizing documented submittal review and observation, without testing: Details are given later in this Section.
1. Static LEED Water and Wastewater Efficiency Features: Low flow faucet and shower aerators.
  2. Static LEED Energy Features:
    - a. Exterior windows and doors.
    - b. Envelope and pipe insulation.
  3. Static LEED Indoor Environmental Quality (IEQ) Features:
    - a. IAQ management during construction and turnover.
    - b. Envelope air and moisture control design and integrity.
- K. Commissioning will be directed by the General Contractor and or their designated Commissioning Coordinator in accordance with the Commissioning Authority under the direction of the University.

L. Related Sections

1. The General and Supplementary Conditions, applicable requirements of all Divisions of the Contract Specifications and all Contract Drawings apply to the work of this Section. In the event of conflict between specific requirements of the various documents, the more restrictive or extensive requirement shall govern.
2. Specific commissioning requirements and related issues are given in the following Sections of the Specifications.
3. Division 01, Section 010000, General Requirements: Submittals: Alerts Subcontractor to submittal requirements for commissioning.
4. Division 01, Section 010000, General Requirements: Final Acceptance: Lists some commissioning tasks required for substantial completion and final acceptance.
5. Division 01, Section 013513.13, Cleanroom Certification and Acceptance, Commissioning requirements for lab and clean room process equipment and systems.
6. Division 23, Section 230800, Commissioning of HVAC: Special Mechanical system requirements and testing requirements by system.
7. Division 26, Section 260800, Commissioning of Electrical Systems: Electrical component testing requirements.
8. Division 01, Section 017900, Demonstration and Training: Training requirements.
9. Division 01, Section 010000, General Requirements: O&M manual requirements.
10. Division 23, Section 230500, Common Results for HVAC: Alerts Trade Subcontractor to commissioning in other sections.
11. Division 26, Section 260500, Common Work Results for Electrical: Alerts Trade Subcontractor to commissioning in other sections.

1.2 DEFINITIONS

- A. Active Test: Using hand-held instruments, immediate control system readouts or direct observation to verify performance (contrasted to analyzing monitored data taken over time to make the "observation").
- B. Approval: Acceptance that a piece of equipment, system or issue related to it complies with the Contract Documents.
- C. Architect/Engineer: The prime consultant (Architect) and sub-consultants who comprise the design team, generally the HVAC mechanical designer/engineer and the electrical designer/engineer.
- D. Basis of Design: See Design Basis.
- E. Certified Testing Company: An industry certified company utilizing industry certified technicians on this project who will perform inspections and testing for equipment and systems. This company is not affiliated or owned by the equipment manufacturer.
- F. Commissioning: Commissioning is a systematic process of ensuring that all building systems and assemblies perform interactively according to the University's objectives and requirements. This is achieved by beginning in the design phase and documenting the University's Project requirements and continuing through construction, acceptance and the warranty period with actual verification of function and performance. The commissioning process encompasses and coordinates the traditionally separate functions of system documentation, equipment start-up, control system calibration, testing and balancing, testing and training. The commissioning process does not take away from or reduce the responsibility of the system designers or installing Trade Subcontractors to provide a finished and fully functioning product. Commissioning during the construction phase is intended to achieve the following specific objectives:
  1. Ensure that applicable equipment, systems and assemblies are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing Trade Subcontractors.
  2. Ensure and document that equipment, systems and assemblies function and perform according to the Contract Documents and the University objectives and requirements.
  3. Ensure that O&M manuals are complete.
  4. Ensure that the University operating personnel are adequately trained.
- G. Commissioning Authority: An independent party, not otherwise associated with the A/E team members, CMGC or the Trade Subcontractors. The Commissioning Authority provides assurance to the University of the

General Contractor's responsibility for compliance with the commissioning requirements per the contract documents and ensures the General Contractor and or their designated Commissioning coordinator coordinates the day-to-day commissioning activities in concert with the CMGC's schedule. The Commissioning Coordinator will lead the commissioning meetings in acquiring information from the General Contractor and or their designated Commissioning Coordinator regarding commissioning issues resolution, scheduling report status updates, status/completed checklists, status/completed test procedures etc. The Commissioning Authority will provide recommendations for as needed and or in accordance with the Project Manager in execution of the commissioning phase of the project.

- H. Commissioning Plan: An overall plan, developed before or after bidding, that provides the structure, schedule and coordination planning for the commissioning process. The commissioning plan includes details of the commissioning scope; systems to be commissioned; rigor of commissioning; team contact information; roles and responsibilities of all players; communication and reporting protocols; commissioning process overview as well as details of submittal activities; construction observation, construction checklist and start-up activities; the process for dealing with deficiencies; test procedure development and execution; O&M manual review and training issues; warranty period activities; description of summary report, description of progress and reporting logs and initial schedule including phasing, if applicable. The Commissioning Authority updates the plan as construction progresses.
- I. Contract Documents: The documents binding on parties involved in the construction of this Project (Drawings, Specifications, Change Orders, Addenda, Contracts, and Requests for Information).
- J. CMGC: The Construction Manager/General Contractor or authorized representative.
- K. Facilities Monitoring and Control System (FMCS): The central building energy management control system.
- L. Construction Checklist: A list of items to include in the installation, start-up and initial checkout of a piece of equipment or assembly. Construction checklists are primarily static inspections and procedures to prepare the equipment or system for initial operation (e.g., belt tension, oil levels, labels affixed, gauges in place, sensors calibrated, etc.). Some construction checklist items entail simple testing of the function of a component, a piece of equipment or system (such as measuring the voltage imbalance on a three phase pump motor of a chiller system). Construction checklists augment and are combined with the manufacturer's start-up checklist. An example is provided as supplement to this Section.
- M. Datalogging: Monitoring flows, currents, status, pressures, etc., of equipment using stand-alone dataloggers separate from the control system.
- N. Deferred Tests: Tests that are performed later, after substantial completion, due to partial occupancy, equipment, seasonal requirements, design or other site conditions that disallow the test from being performed.
- O. Deficiency: A condition in the installation or function of a component, piece of equipment or system that is not in compliance with the Contract Documents (that is, does not perform properly or is not complying with the University's objectives).
- P. Design Basis: The basis and assumptions for calculations, decisions, schemes and product selections to meet the University's Project requirements and objectives and to satisfy applicable regulatory requirements, standards and guidelines.
- Q. Design Narrative: A narrative submitted with each design submittal describing the concepts and features in the Drawings. The Design Narrative is written by the designer and is updated and increases in detail with each phase of the design. Initially, it may describe general building and space use and later should include detailed space usage and system and assembly descriptions.
- R. Design Record: The compilation of the following five elements: University Project Requirements, University Objectives, Design Narrative, Design Basis and Performance Metrics.
- S. Documenting Tests: The recording of what actions were taken to perform each individual test procedure, along with the results or system response of the procedure, with any deficiencies noted.
- T. Emergency Power and Fire Alarm Response Matrix: A matrix listing all equipment and components (air handlers, dampers, valves, fire doors, elevators, control system, security system, lighting, etc.) with their status

and action after each fire alarm initiation type, under emergency power and the requirements to bring each system back on line.

- U. Factory Testing: Testing of equipment on-site or at the factory by factory personnel with the University present.
- V. Indirect Indicators: Indicators of a response or condition, such as a reading from a control system screen reporting a damper to be 100 percent closed.
- W. Issues Log: Ongoing record of the issues identified during the commissioning process that require or did require correction. For each entry the log includes a unique identification number, identification date, identification party, a short description of the issue, the equipment or assembly it is associated with, a long description of the issue, including cause, implications of the issue, recommendations for correction, assignment of responsibility for correction, an issue closed date and the name of the party verifying the correction. The Commissioning Authority is responsible to maintain the log.
- X. Manufacture's Service Representative (MSR): A company that is certified and trained by a manufacturer to provide startup, testing, and troubleshooting service for equipment.
- Y. Monitoring: The recording of parameters (flow, current, status, pressure, etc.) of equipment operation using dataloggers or the trending capabilities of control systems.
- Z. NETA: International Electrical Testing Association, Inc.
- AA. Non-Compliance: See Deficiency.
- BB. Non-Conformance: See Deficiency.
- CC. Over-written Value: Writing over a sensor value in the control system to see the response of a system (e.g., changing the outside air temperature value from 50 degrees F to 75 degrees F to verify economizer operation). See also "Simulated Signal."
- DD. University: The representative on the Project that has the authority to act in the University's behalf in all issues.
- EE. University-Contracted Tests: Tests paid for by the University outside the CMGC's contract and for which the Commissioning Authority does not oversee. These tests will not be repeated during tests if properly documented.
- FF. University Objectives: A distillation of the most salient concepts within the University's Project Requirements considered important to the University to have in writing and to be tracked through design and construction. The University Objectives are sometimes referred to as the design intent.
- GG. University Project Requirements: Documentation of the functional requirements of the facility and the expectations of how it will be used and operated. This includes Project and design goals, measurable performance criteria, budgets and schedules and supporting information. This document is analogous to what has traditionally been referred to as the University Program.
- HH. Performance Metrics/Benchmark: Measurable indicators that allow verification that a specific University Objective or Requirement or element in the Design Narrative has been met. Performance Metrics are identified throughout the design of the Project with as many as possible being generated during the development of the University Objectives. Metrics are most applicable for those University Objectives that allow for a numerical quantitative evaluation. However, some University Objectives may have Performance Metrics that are not numerical.
- II. Phased Commissioning: Commissioning that is completed in phases (by floors, for example) due to the size of the structure or other scheduling issues, in order minimize the total construction time.
- JJ. Sampling: Functionally testing only a fraction of the total number of identical or near identical pieces of equipment.

- KK. Seasonal Tests: Tests that are deferred until the system(s) will experience conditions closer to their design conditions.
- LL. Simulated Condition: Condition that is created for the purpose of testing the response of a system (e.g., applying a hair blower to a space sensor to see the response in a VAV box).
- MM. Simulated Signal: Disconnecting a sensor and using a signal generator to send an amperage, resistance or pressure to the transducer and DDC system to simulate a sensor value.
- NN. Specifications: The construction Specifications of the Contract Documents.
- OO. Start-up: The initial starting or activating of dynamic equipment, including executing construction checklists.
- PP. Trade subcontractor: A sub-tier Contractor to the CMGC.
- QQ. Systems Manual: A manual providing to the immediate and future operating staff the information needed to understand and optimally operate each system. The manual is in addition to the O&M Manuals submitted by the CMGC. The systems manual focuses on operating, rather than maintaining the equipment, particularly the interactions between equipment. Some components of the manual may reside in the CMGC-submitted O&M Manuals.
- RR. Test: Assessments that verify specific components, assemblies, systems, and interfaces among systems function and perform in accordance with the University's objectives and the Contract Documents. Testing may include using manual (direct observation) or monitoring methods. Testing is the dynamic testing of specific and interacting equipment and systems in full operation. Tests are generally performed after construction checklists and start-up are complete. Some procedures in construction checklists test components, but reference to "testing" generally refers to those equipment and system tests conducted after Trade Subcontractor startup and initial checkout.
- SS. Test Procedures (TP): The written procedures and documentation forms of tests used to guide and record testing. For mechanical systems, TPs are composed of repeatable, step-by-step procedures and include the test prerequisites, the test process, the expected outcomes and acceptance criteria. Forms or space for recording the results of tests may be included integrally in the written procedures or attached on separate sheets. For electrical component testing, the procedures may be less step-by-step-like than for dynamic mechanical equipment. For each piece of equipment, checks and test procedures and their documentation record forms may be different documents or combined in the same document, but checks and tests should be grouped. Responsibility for test procedure development is shared between the Commissioning Authority and the Trade Subcontractor according to the Check and Check and Testing Responsibility Table, attached as a supplement to this Section.
- TT. Test Requirements: Requirements specifying what modes and functions, etc., shall be tested. The test requirements are not the detailed test procedures.
- UU. Trending: Monitoring using the building control system.
- VV. Vendor: Supplier of equipment.
- WW. Warranty Period: Refer to Division 01, Section 010000, General Requirements, for a technical definition relative to equipment. For commissioning purposes and where referenced in a commissioning section, Warranty Period is defined as one year from substantial completion.

### 1.3 RESPONSIBILITIES

- A. Overview: The responsibilities of the non-CMGC or Trade Subcontractor parties in the commissioning process are summarized in the following articles. It is noted that the services for the University, Architect, mechanical and electrical designers/Engineers, and Commissioning Authority are not provided for in this Contract. That is, the CMGC or Trade Subcontractor is not responsible for providing their services. Their responsibilities are listed here to clarify the commissioning process. Additional responsibilities of subcontractors to the CMGC are found in other Sections of Division 01, General Requirements.

- B. Architect and Mechanical and Electrical Engineers of Record:
1. All tasks of the designers are applicable only if it is within their contracted scope of services.
  2. Construction Phase:
    - a. Review the Commissioning Plan.
    - b. Attend the commissioning planning and kick-off meetings and selected commissioning team meetings.
    - c. The mechanical and electrical engineer attend the controls integration meetings.
    - d. Perform normal submittal review, construction observation, O&M manual review.
    - e. With the Trade Subcontractors and Commissioning Authority, actively assist in the development of the emergency power and fire alarm response matrix.
    - f. Review the coordination Drawings.
    - g. Assist (along with the ) in clarifying the operation and control of commissioned equipment in areas where the Specifications, control Drawings or equipment documentation is not sufficient for writing detailed testing procedures.
    - h. Witness selected testing.
    - i. Coordinate resolution of system deficiencies and warranty issues identified during commissioning.
    - j. Provide an overview of system design and function during selected operator trainings.
    - k. Provide design basis and design narratives documentation for the Systems Manual.
    - l. Review Systems Manual.
  3. Warranty Period: Coordinate resolution of design non-conformance and design deficiencies identified during warranty-period commissioning activities.
- C. Commissioning Authority:
1. Construction Phase:
    - a. The primary role of the Commissioning Authority is to develop and coordinate the execution of a process of improved equipment installation and checkout and to verify and document that systems are functioning in accordance with the documented objectives of the University and in accordance with the Contract Documents. The Commissioning Authority is not responsible for design concept, design criteria, compliance with codes, design or general construction scheduling, cost estimating, or construction management, unless specifically stated otherwise in the Contract Documents. The Commissioning Authority may assist with problem-solving non-conformance or deficiencies, but ultimately that responsibility resides with the CMGC and Trade Subcontractors.
    - b. Coordinate the commissioning work and with the CMGC to ensure that commissioning activities are being scheduled into the master schedule. The General Contractor and or their designated Commissioning Coordinator will provide a detailed schedule within the Master Construction Schedule that includes all systems, required tasks/activities inclusive of necessary permits, work tasks, safety compliance steps, etc by the mid-point of construction to the University and the Commissioning Authority.
    - c. Revise, as necessary, the construction phase commissioning plan developed during design, including scope and schedule.
    - d. Plan and conduct commissioning meetings including the planning and kick-off meetings as needed and distribute minutes.
    - e. Request and review additional information required to perform commissioning tasks, including O&M materials, Trade Subcontractor start-up and checkout procedures. Before start-up, gather and review the current control sequences and interlocks and work with Trade Subcontractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
    - f. Equipment List Matrix.
      - 1) Develop an equipment list matrix of commissioned equipment in a computerized spreadsheet in a grouped and organized format.
      - 2) Include:
        - a) Brief equipment or system name
        - b) Tag or ID number
        - c) Governing specification section
        - d) Submittal reference number
        - e) Installation location by room number or coordinates
    - g. Track status of each piece of equipment in the equipment list matrix for: receipt of documentation, submittal reviewed, construction checklist development and execution progress, startup, test form development and execution, trend log completion, O&M manual submission, training agenda development or receipt and training completion, red-line document submission and opposite season testing.

- h. Develop the format for, and coordinate the completion of the emergency power and fire alarm response matrix as defined in this Section.
- i. Review normal Trade Subcontractor submittals applicable to systems being commissioned concurrent with the A/E reviews for compliance with commissioning and O&M manuals and coordination issues.
- j. Review requests for information and change orders for impact on commissioning and University's objectives.
- k. Review coordination Drawings and ensure that trades are making a reasonable effort to coordinate.
- l. Review Trade Subcontractor's developed start-up and initial systems checkout plans with the Trade Subcontractors for selected equipment.
- m. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
- n. Coordinate with the Architect to verify that any sustainable design requirements affected by system performance or commissioning are addressed.
- o. Document construction checklist completion by reviewing completed construction checklists and by selected site observation.
- p. Document systems start-up by reviewing start-up reports and by selected site observation.
- q. Write step-by-step test procedures and documentation formats for commissioned equipment and assemblies, as assigned in the Check and Check and Testing Responsibility Table provided as a Supplement to this Section. Test procedures will include active testing, energy management control system trending and may include stand-alone data-logger monitoring.
  - 1) Existing written testing requirements and procedures in accepted or required standards, guidelines or Specifications will suffice as the test procedures for the following: Regulated tests such as fire alarm, fire suppression, elevators, NETA electrical equipment tests, test procedures within these specifications and common Trade Subcontractor tests such as duct and piping tests.
- r. Coordinate and assist in development of test plans, execution and documentation of tests of commissioned equipment overseen by regulatory authorities and ensure that such tests meet the testing and documentation rigor desired by the University. The systems for which this applies are indicated in the Check and Testing Responsibility Table in the supplements to this Section. Testing and commissioning for these systems shall be per the requirements of those Sections of the Specifications and the governing codes and standards. The Commissioning Authority shall work with the CMGC and Trade Subcontractors and University to ensure that these tests are scheduled and coordinated with the interfaces to other systems on the Project as well as requirements of the authorities having jurisdiction. Coordination efforts shall include but not be limited to:
  - 1) Developing a logical test plan that flows from the component level on the various systems to the integrated testing of the systems as they interact with each other.
  - 2) Verification that all necessary documentation requirements are met for all parties including but not limited to the authorities having jurisdiction, the University and the insurance underwriter.
  - 3) Promoting and being proactive in the process and ensuring that all involved parties communicate effectively across the inter-discipline boundaries as required for successful integrated testing of the systems.
- s. Coordinate testing for all commissioned systems and assemblies. Witness and document active tests performed by the Trade Subcontractors for all commissioned systems and assemblies, except: a) some smaller equipment may be tested and documented by the Trade Subcontractors, at the Commissioning Authority's discretion, b) electrical equipment testing and regulated testing may be directed and documented by the Trade Subcontractor with only spot witnessing and report review by the Commissioning Authority. Refer to the Check and Testing Responsibility Table provided as a supplement to this Section for more specific delineation. The testing shall include operating the system and components through each of the written sequences of operation, and other significant modes and sequences, including start-up, shutdown, unoccupied mode, manual mode, staging, miscellaneous alarms, power failure, security alarm when impacted and interlocks with other systems or equipment. Sensors and actuators shall be calibrated during construction check listing by the installing Trade Subcontractors, and spot-checked by the commissioning provider during testing. Analyze functional performance trend logs and monitoring data to verify performance. Coordinate retesting as necessary until satisfactory performance is achieved.

- t. After active testing and initial trouble shooting is complete, monitor system operation and performance for selected data points for up to 2 weeks by requesting trend logs from the Trade Subcontractor from the building automation system. Analyze monitored data to verify operation and performance and issue a written report.
  - u. Maintain a master Issues Log and a separate record of testing. Report all issues as they occur directly to the University. Provide directly to the University written progress reports and test results with recommended actions.
  - v. Review equipment warranties to ensure that the University responsibilities are clearly defined.
  - w. Oversee and approve the training of the University's operating personnel.
  - x. Review and approve the preparation of the O&M manuals for commissioned equipment.
  - y. Compile a Commissioning Record.
  - z. Compile a Systems Manual according to the definition and description in this Section for all commissioned systems.
2. HVAC and Mechanical-Specific Tasks of the Commissioning Authority
- a. Controls Integration Meetings: Coordinate the approval process for the control system database and programming (point names, alarm limits, access levels, graphic details and layout, specific control strategies and sequences, etc.) via a series of meetings attended by the Trade Subcontractor, University, and Mechanical Engineer. The meetings shall occur after the software and data base drawings are issued for initial review, but prior to the development of the database and code for any piece of equipment.
  - b. Witness HVAC piping pressure test and flushing, sufficient to be confident that proper procedures were followed. Include documentation of all testing in the Commissioning Record.
  - c. Witness any ductwork testing and cleaning sufficient to be confident that proper procedures were followed. Include documentation of all testing in the Commissioning Record.
  - d. Approve air and water systems balancing by selected site observation, by reviewing completed reports and by spot testing.
  - e. Coordinate and approve the start-up of permanent equipment for temporary space conditioning during construction and review the plans for the use of temporary space conditioning equipment.
3. Process Systems Commissioning:
- a. Refer to Division 01, Section 013513.13, Cleanroom Certification and Acceptance, for specific requirements.
4. Electrical System Specific Tasks of the Commissioning Authority: See Division 26, Section 260800, Commissioning of Electrical Systems, for Electrical System Requirements.
5. Static LEED Systems:
- a. Refer to the Static elements commissioning article later in this Section.
6. Warranty Period:
- a. Coordinate and supervise required opposite season or deferred testing and deficiency corrections and provide the final testing and sequence of operation update documentation for the Commissioning Record and O&M manuals.
  - b. Return to the site approximately 10 months into the 12 month warranty period and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have with operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify deficiencies that may come under warranty or under the original construction contract. Assist facility staff in developing reports and documents and requests for services to remedy outstanding problems.
- D. University:
- 1. Construction Phase:
    - a. Furnish a copy of all Construction Documents, addenda, requests for information, change orders and approved submittals and Shop Drawings related to commissioned equipment to the Commissioning Authority for their permanent retention.
    - b. Facilitate the coordination of the commissioning work by the Commissioning Authority.
    - c. With the CMGC and Commissioning Authority, ensure that commissioning activities are being scheduled into the master schedule.
    - d. Arrange for facility operating and maintenance personnel to attend various field commissioning activities and field training sessions according to the Commissioning Plan.
    - e. Participate in issue resolution as necessary.
    - f. Provide final approval for the completion of the commissioning work.
  - 2. Warranty Period: Ensure that any seasonal or deferred testing and any deficiency issues are addressed.

- E. General Contractor (GC)/CMGC
1. The GC/CMGC is fully responsible to the University for all Trade Subcontractor and CMGC listed responsibilities in the specifications. Separate responsibility listings are given in this Section for clarity purposes.
  2. Construction Phase.
    - a. It is a requirement that the General Contractor (GC) /CMGC shall provide / designate a Commissioning Coordinator to organize, schedule, coordinate and direct the execution of the GC/CMGC's and Trade Subcontractor's commissioning responsibilities. The Commissioning Coordinator shall have experience in project management, scheduling and in the technical aspects of mechanical and electrical systems including commissioning of applicable equipment and systems. The General Contractor will submit resume(s) with applicable experience and references of their potential/selected Commissioning Coordinator. The General Contractor will be responsible for the selection of and or replacement of their designated Commissioning Coordinator at the GC's expense should their Commissioning Coordinator not demonstrate acceptable performance throughout the contracted project at the discretion of the GC and or University. If the General Contractor refuses to provide for a Commissioning Coordinator, the University shall provide for that requirement at the General Contractor's expense.
    - b. With the Commissioning Authority ensure that commissioning activities are being scheduled into the master schedule. The General Contractor and or their designated Commissioning Coordinator will provide a detailed schedule within the Master Construction Schedule that includes all systems, required tasks/activities inclusive of necessary permits, work tasks, safety compliance steps, etc by the mid-point of construction to the University and the Commissioning Authority.
    - c. Include Trade Subcontractor's cost associated with commissioning in the total contract price.
    - d. Furnish a copy of all submittals and Shop Drawings related to commissioned equipment to the Commissioning Authority for their permanent retention during the normal submittal review cycle.
    - e. In each purchase order or subcontract written, include requirements for submittal data, O&M data, commissioning tasks and training that will meet the requirements of the Specifications.
    - f. Notify the Commissioning Authority when the installation will begin for static assemblies that are being commissioned, dates for pipe and duct system testing, flushing, cleaning, start-up of each piece of equipment and starting of testing adjusting and balancing. Notify the Commissioning Authority ahead of time, when commissioning activities not yet performed or not yet scheduled may delay construction.
    - g. Write and distribute construction checklists for equipment to be commissioned as assigned in this Section.
    - h. Provide time in selected construction meetings to cover commissioning-related issues.
  3. Warranty Period.
    - a. Schedule and coordinate the Trade Subcontractors in correcting outstanding commissioning tasks and deficiencies.
- F. GC/CMGC and Trade Subcontractors:
1. The details of this article apply to both the CMGC and sub-tier Subcontractors providing commissioned equipment. Other responsibilities for each party are listed in individual articles specific to each party.
  2. Construction Phase.
    - a. Coordinate with the Commissioning Authority to facilitate the commissioning work.
    - b. Be proactive in seeing that commissioning processes are executed and that the requirements of the Commissioning Authority for the commissioning work are coordinated into the over-all construction schedule.
    - c. Attend the commissioning planning and kick-off meetings and other necessary meetings scheduled by the Commissioning Authority to facilitate the commissioning process.
    - d. Participate in the controls integration meetings coordinated by the Commissioning Authority, prior to submitting the controls submittal.
    - e. With the Architect and Commissioning Authority, actively assist in the development of the emergency power and fire alarm response matrix during the initial submittal period.
    - f. The CMGC and Trade Subcontractors shall respond to notices of issues identified during the commissioning process, making required corrections or clarifications and returning prompt notification to the Commissioning Authority.
    - g. When completion of a task or other issue has been identified as holding up any commissioning process, particularly functional testing, the Trade Subcontractor shall notify the CMGC within one day of identification. The CMGC shall within two days of notification of the issue, notify the Commissioning Authority and provide an expected date of completion or resolution of the issue. The CMGC shall notify the Commissioning Authority within one day of completion. It is not the

responsibility of the Commissioning Authority to obtain this status information through meeting attendance, asking questions or field observation.

G. Trade Subcontractors:

1. Construction Phase:

- a. In addition to the other responsibilities for the Trade Subcontractors listed in this Section, provide additional requested documentation, prior to normal O&M manual submittals, to the Commissioning Authority for development of functional and performance testing procedures.
- b. Typically this will include detailed manufacturer installation, start-up, operating, troubleshooting and maintenance procedures, full details of any University-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the University to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority.
- c. The Trade Subcontractor shall provide the Commissioning Authority, GC and Commissioning Coordinator additional documentation necessary for the commissioning process, when requested. This will include prior to the commissioning phase, a complete list of all equipment and/or materials necessary in completing the construction phase and or installation of all equipment and systems, noting what inventory is on site, installed, and what may need to be ordered, and received to complete construction. Any outstanding items that may need to be expedited will be done by the respective sub-contractor under the General Contractor's responsibility and expense in order to stay within the construction schedule.
- d. Assist in clarifying the operation and control of commissioned equipment or assemblies in areas where the Specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- e. Submit a written plan to the University and Commissioning Authority for temporary startup of equipment used for space conditioning. Obtain plan approval of University and Commissioning Authority prior to such startup.
- f. Notify the GC/CMGC and or their Commissioning Coordinator when the installation will begin for static assemblies that are being commissioned, dates for pipe and duct system testing, flushing, cleaning, start-up of each piece of equipment and starting of testing adjusting and balancing. Provide significant advance notification to the GC/ CMGC and or their Commissioning Coordinator ahead of time and prior to commissioning/project meetings, when commissioning activities not yet performed or not yet scheduled may delay construction. Also provide solutions to resolve the delay prior to and or with the notification.
- g. During the installation, start-up and initial checkout process, document the execution of installation, start-up and initial checkout with parties having direct knowledge of each item being checked off and provide a copy to the Commissioning Authority.
- h. During construction, maintain red-line documents for Trade Subcontractors-generated coordination drawings. Update after completion of commissioning (excluding deferred seasonal testing).
- i. Record daily all issues that arise during the testing, adjusting and balancing work, such as damaged or missing duct or insulation, sensors, wiring, valves, dampers, controls, programming, equipment, components, etc. or items that will reduce the effectiveness of the installation or prevent accurate air and water balancing or systems or building control. During balancing, provide the Commissioning Authority this list of issues once a week within 1 day of the end of the reported week.
- j. Review test procedures developed by the Commissioning Authority to ensure feasibility, safety and equipment protection and provide necessary alarm limits to be used during the tests.
- k. Develop test plans with review and approval of the Commissioning Authority per the Check and Testing Responsibility Table provided as a supplement to this Section.
- l. Write step-by-step test procedures and documentation formats for commissioned equipment and assemblies, as assigned in the Check and Testing Responsibility Table provided as a Supplement to this Section. Test procedures will include active testing, energy management control system trending and may include stand-alone data-logger monitoring.
- m. Existing written testing requirements and procedures in accepted or required standards, guidelines or Specifications will suffice as the test procedures for the following: Regulated tests such as fire alarm, fire suppression, elevators, NETA electrical equipment tests, test procedures within these specifications and common industry tests such as duct and piping tests.
- n. Execute testing for selected systems and assemblies under the direction of the GC and or their Commissioning Coordinator in accordance with, and documented by the Commissioning Authority as listed in the Check and Testing Responsibility Table. Direct, execute, and

document testing on selected systems as listed in the Check and Testing Responsibility Table provided as a supplement to this Section.

- o. Assist and cooperate with the Commissioning Authority by putting all commissioned equipment and systems into operation and continuing the operation during each working day of testing, as required.
- p. Remedy outstanding Architect "punch list" items that may affect equipment operation before testing. Air and water testing adjusting and balancing shall be completed with discrepancies and problems remedied before testing of the respective air- or water-related systems.
- q. Provide all tools or the use of tools to start, check-out and functionally test equipment and systems, except for specified testing with portable data-loggers, which shall be supplied and installed by the Commissioning Authority.
- r. Provide skilled technicians and perform testing under the direction of the Commissioning Authority for equipment and assemblies specified for testing in this Section. In particular, the person tasked with operating the controls system during testing shall be familiar with this building and control program. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete necessary tests, adjustments and problem-solving. For larger mechanical equipment, provide the services of the start-up technician for the beginning of the testing of the equipment.
- s. Ensure that the local authorities having jurisdiction are available to witness any acceptance test (e.g., fire alarm testing, smoke cycle testing, fire damper acceptance testing, sprinkler system hydro-testing, etc.) that is a condition of occupancy for the building.
- t. Provide assistance to the Commissioning Authority in interpreting apparent system performance problems from monitored and test data.
- u. Respond in writing to each issue. Correct deficiencies (differences between specified and observed performance) as interpreted by the Commissioning Authority, University and Architect and retest the equipment.
- v. Train University personnel using expert qualified personnel according to the Contract Documents.
- w. Prepare O&M manuals, according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions, and submit a copy to the Commissioning Authority for review.
- x. Provide necessary documentation for the Systems Manual as described in this Section.
- y. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty during occupancy. Provide this information to the University.
- aa. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty during occupancy. Provide this information to the University.
- bb. Designate the Contractor's mechanical, electrical, plumbing (MEP) superintendent and/or employ a professional Commissioning Authority/Agent to act as the Commissioning Coordinator for the Contractor with the following responsibilities. The Commissioning Coordinator may have other project responsibilities, but the priority will be:
  - 1) Direct, organize, schedule and coordinate the commissioning activities for the Contractor and facilitate systems being installed, started up and checked out in sequence to accommodate all testing /commissioning in accordance with the Commissioning Authority.
  - 2) Beginning at least 60 days prior to starting up the first major piece of HVAC equipment, generate and manage a Construction Completion Issues Log that tracks issues of commissioned systems that are late, holding up the critical path, are long lead items, need special coordination or are somewhat contested. This is not the same as the Commissioning Authority's Commissioning Issues Log which focuses on deficiencies identified during inspection and testing.
  - 3) Attend all commissioning meetings.
  - 4) Direct the timely resolution and correction of issues that arise during the commissioning process.
  - 5) Track and encourage progress on the filling out of the construction checklists by trade subcontractors.
  - 6) Monitor progress of the balancing contractor and ensure they are following the specifications and balancing plan.
  - 7) Prior to functional testing, ensure that trade subcontractors have completed a thorough checkout of their systems, have reviewed the functional test procedures and have confirmed the equipment and system is ready for functional testing.
  - 8) Work with the Commissioning Authority in creating and managing the functional testing schedule.
  - 9) Maintain a set of the sequences of operation and control drawings that have all updates, changes and clarifications redlined.

- 10) Prior to their generation, review the Contractor's format and content plan for the O&M manuals to ensure it is consistent with the specifications.
- 11) Prior to training, review the Contractor's format and content plan for operator training to ensure it is consistent with the specifications. Track status for completion of all training provided by the Subcontractor(s) in accordance with the with the contract specifications.
- 12) Provide coordination, directing, documentation, witnessing, etc. of functional tests as shown on the Check and Testing Responsibility Table.
- 13) During Warranty Period:
  - a) Coordinate seasonal or deferred testing, witnessed by the Commissioning Authority, according to the Specifications.
  - b) Correct deficiencies and make necessary adjustments to O&M manuals and Record Documents for applicable issues identified in any seasonal or warranty period testing.

2. Warranty Period:
  - a. Correct deficiencies and make necessary adjustments to O&M manuals and red-line documents for applicable issues identified in any seasonal or warranty period testing.

H. Equipment Suppliers:

1. Construction Phase:
  - a. Provide requested submittal data, including detailed start-up and checkout procedures and specific responsibilities of the University to keep warranties in force for all commissioned equipment or assemblies.
  - b. Assist in equipment or assembly testing per agreements with Trade Subcontractors.
  - c. Include all special tools and instruments, when only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents in the base bid price to the CMGC or Trade Subcontractors.
  - d. University to provide information requested by Commissioning Authority regarding equipment sequence of operation and testing procedures.
  - e. Review test procedures for equipment installed by factory representatives.
  - f. For larger primary equipment, provide the services for the first part of testing, of the technician that conducted start-up. For electrical commissioning, see Table of Testing Responsibility provided as a supplement to this Section.
  - g. Provide expert qualified staff for equipment training.

1.4 SUBMITTALS

- A. The CMGC and Trade Subcontractors shall provide the Commissioning Authority with information required to facilitate the commissioning process from written requests.
- B. Standard Equipment and Assembly Submittals.
  1. Prior to standard equipment and assembly submittals being issued, the CMGC shall provide the Commissioning Authority with a submittal register. The Commissioning Authority will check which submittals they desire to review and comment on and which they need only copies of the approved submittals.
  2. The submittals reviewed may be done in parallel with A/E reviews or in series with them, depending on protocol set by the University.
  3. The reviews will consist of commenting relative to conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment, adequacy for developing test procedures and for O&M issues. The reviews are intended primarily to aid in the development of testing procedures and only secondarily to verify compliance with equipment Specifications.
- C. Other Equipment and Assembly Information.
  1. When not included with the standard submittals, the Trade Subcontractors shall provide to the Commissioning Authority requested shop drawings, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of University contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Authority. This documentation will be required prior to the normal O&M manual submittals.

- D. All equipment and assembly documentation requested by the Commissioning Authority shall be included by the Trade Subcontractors later in the O&M manuals.
- E. The Trade Subcontractors shall submit all company and required staff qualifications.
- F. The Trade Subcontractors shall submit checklists and startup and test plans, forms and procedures as indicated on the Check and Testing Responsibility Table.
- G. The Trade Subcontractors and Architect shall provide additional design narrative information requested by the Commissioning Authority, depending on the completeness of the Design Record documentation and sequences provided with the Specifications.

#### 1.5 QUALITY ASSURANCE

- A. Test Equipment:
  - 1. All standard testing equipment required for the Trade Subcontractors to perform installation, start-up and initial checkout and required testing shall be provided by the Trade Subcontractors.
  - 2. Special tools and instruments, only available from vendor, specific to a piece of equipment, required for testing equipment according to these Contract Documents shall be included in the base bid price.
  - 3. The Trade Subcontractors shall provide datalogging equipment for setting up and testing of cold rooms, clean room certification, fume hoods and lab room pressurization, and equipment required to perform specified electrical equipment testing.
  - 4. Datalogging equipment required for testing equipment in support areas shall be provided and used by the Commissioning Authority.
- B. Test Equipment Calibration Verification:
  - 1. Trade Subcontractors shall submit, within 90 days of notice to proceed and 30 days before any testing is performed, documentation of meeting the following calibration requirements.
  - 2. Electrical equipment testing instruments must be calibrated in accordance with the following frequency:
    - a. Field Instruments: Analog, 6 months maximum, digital, 12 months maximum.
    - b. Laboratory Instruments: 12 months.
    - c. Leased specialty equipment: 12 months where accuracy is guaranteed by lessor.
  - 3. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications.
    - a. If not otherwise given, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5 degrees F and a resolution of + or - 0.1 degrees F. Pressure sensors shall have an accuracy of + or - 2.0 percent 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.

#### 1.6 COORDINATION

- A. Commissioning Team: The members of the commissioning team consist of the Commissioning Authority, the University, the CMGC, the Architect and design engineers, the mechanical contractor, the electrical contractor, the testing adjusting and balancing contractor, the controls contractor, any other installing subcontractors or suppliers of commissioned equipment or assemblies and the University's building or plant operator/Engineer.
- B. Management: The Commissioning Authority is hired by the University directly. The Commissioning Authority directs and coordinates the commissioning activities and reports to the University. All members work together to fulfill their contracted responsibilities and meet the objectives of the Contract Documents.
- C. Scheduling: The CMGC shall provide sufficient notice to the Commissioning Authority regarding the installation of static assemblies being commissioned and the schedule for the construction checklists, start-up and initial checkout of all commissioned dynamic equipment and systems. Refer to Schedule under Part 3, EXECUTION, for additional scheduling details.

- D. Meetings: Refer to Part 3, EXECUTION, for a description of meetings required as part of the commissioning process.
- E. General: The CMGC and the Trade Subcontractors will coordinate with the Commissioning Authority in a number of areas as described in this Section in order to facilitate the successful completion of the commissioning plan.

PART 2 - PRODUCTS NOT USED

PART 3 - EXECUTION

3.1 MEETINGS

- A. Planning Meeting: Within 30 days of commencement of construction, the Commissioning Authority will schedule, plan and conduct a commissioning planning meeting with the Architect, and mechanical and electrical engineering subconsultants, the CMGC, University and facility operator or representative. During this meeting, the overall scope and process of the commissioning effort for this Project will be described, issues and suggestions from all parties given, management and reporting protocols finalized and the Project schedule discussed. From information gathered in this meeting, the Commissioning Authority will update the Commissioning Plan preparatory to the commissioning kick-off meeting. Meeting minutes will be distributed to all parties by the Commissioning Authority.
- B. Kick-off Meeting: Within 30 days from the planning meeting, the Commissioning Authority will schedule, plan and conduct a commissioning kick-off meeting with the entire commissioning team in attendance, including the controls, sheet metal, electrical, mechanical, test, adjusting and balancing and other appropriate Trade Subcontractors and the facility operator or representative in attendance. One week prior to this meeting, the updated commissioning plan will be distributed to all members for their review. The commissioning plan, the overall commissioning process and general responsibilities of each team member, reporting and communication protocols and next steps will be discussed. Meeting minutes will be distributed to all parties by the Commissioning Authority.
- C. Temporary or Early Startup of Equipment. When equipment will be used in a temporary mode prior to operating the equipment permanently, a meeting shall be held that discusses the issues surrounding indoor environmental quality, moisture intrusion, building pressurization, duct and equipment cleanliness, checkout of safeties and fire alarm and protection, etc.
- D. Miscellaneous Meetings: Deficiencies in compliance with the contract documents identified through the commissioning process or other means shall be discussed, as needed, in portions of regular construction meetings. Meetings dedicated to deficiencies or commissioning: status, coordination and planning shall also be conducted. The Commissioning Authority will plan, conduct and take minutes at commissioning meetings. When practical, commissioning meetings will be an appendage to regular construction meetings. All commissioning meetings shall be attended by the CMGC, the mechanical and the controls subcontractors. Selected meetings shall require the attendance of the electrical, sheetmetal, fire alarm, TAB or other trades of commissioned systems or assemblies. The number of specific meetings dedicated to commissioning, besides those specifically listed in this Section are expected to consist of:
  - 1. From 30 days prior to setting ductwork or mechanical equipment until the startup of the first piece of major mechanical equipment: 1 hour meetings every 6 weeks.
  - 2. From the startup of the first piece of major mechanical equipment until the beginning of functional testing of mechanical equipment: 1 hour meetings every two weeks.
  - 3. From the beginning of functional testing of mechanical equipment until all mechanical equipment has had the first round of testing conducted: 1 hour meetings once a week.
  - 4. From the end of the first round of testing until all deficiencies are corrected: 1 hour meetings once a week or as set by the University.
  - 5. If the number of deficiencies is abnormal or coordination or cooperation is insufficient, additional meetings or meeting durations shall be required.
- E. Controls Integration Meetings: The Commissioning Authority coordinates a series of meetings to go over the control drawings, sequences of operation, points list and database and controls submittal requirements. These

meetings are held prior to a formal control drawing submittal and any programming. The intent is to clarify control related issues for the controls contractor, mechanical, fire alarm and electrical contractor, University facility staff and Commissioning Authority prior to final point database development, programming and the formal control drawing submittal.

1. The controls contractor shall attend all meetings. The mechanical, electrical and general contractor shall attend when issues regarding equipment they are responsible for are discussed. The mechanical and electrical designers attend as needed according to their contracts. The control technicians attending the meetings must be the same technicians that are/will install and program the DDC system.
2. Preliminary control drawing submittals and sequences by system are provided by the Controls Contractor, reviewed beforehand and discussed at these meetings.
3. Primary issues discussed and clarified are:
  - a. Control drawing content and format
  - b. Point database (points (monitored points, software points, naming conventions, alarms, report format)
  - c. Sequences of operation and setpoints (clarity, completeness, design intent, functionality, and enhancements for control, energy and O&M)
  - d. Interlocks to packaged controls and other systems, including filling in the fire alarm and emergency power response matrices
  - e. Operator workstation graphics
  - f. Field sensor and panel locations
4. A site walk-through with the Controls Contractor, Commissioning Authority and Engineer shall be conducted where precise locations of panels, sensors, thermometers, flow meters and stations and valve taps will be identified.
5. The Commissioning Authority takes minutes at these meetings, which may include marked up data base forms and sequences of operation.

### 3.2 CONSTRUCTION CHECKLISTS, START-UP, AND INITIAL CHECKOUT

- A. The following procedures apply to all equipment and assemblies to be commissioned:
1. **Static Elements:** Systems or assemblies that are static in nature (not dynamic like mechanical or some electrical systems) may have very simplified construction checklists for installation and may have no start-up or testing requirements. Refer to the Static Elements article later in this Section for specific requirements.
  2. **Construction Checklists:**
    - a. The CMGC develops new or adapts existing representative construction checklists and procedures for commissioned equipment and assemblies according to the notation in the list of commissioned systems in Part 1, GENERAL, of this Section. A representative checklist for mechanical systems is found as a supplement to this Section. Electrical equipment component check forms are considerably simpler than the mechanical example.
    - b. **Calibrations:** The construction checklists will contain requirements for calibrations when applicable. The Trade Subcontractors is responsible to calibrate all field-installed sensors and actuators using test and documentation methods approved by the Commissioning Authority.
    - c. On each Construction Checklist the CMGC shall identify which trade or contractor is responsible for executing and documenting each of the line item tasks and shall note that trade on the checklist form.
    - d. Checklists may be attached to test procedure forms.
  3. **Manufacturer Installation and Startup Procedures:**
    - a. The Trade Subcontractors shall document their installation and startup utilizing manufacturer installation and startup procedures, check sheets and reports, in addition to the commissioning construction checklists.
    - b. The completed manufacturer startup reports shall be submitted to the Commissioning Authority within 5 days of startup. The Contractor shall clearly note any items that have not been completed and the plan for their completion.
  4. **Execution of Construction Checklists and Start-up:**
    - a. Each piece of equipment shall receive full construction checkout by the Trade Subcontractors following the approved plan and forms. No sampling strategies are used. Only individuals that have direct knowledge and witnessed that a line item task on the construction checklist was actually performed shall initial or check that item off. It is not acceptable for non-witnessing supervisors to fill out the forms.
    - b. The Trade Subcontractors shall complete the pre-start procedures in the construction checklist prior to starting equipment, including but not limited to verification of completion of wiring,

safeties, lubrication, drive rotation and proper electrical test readings. Startup shall be conducted under supervision of responsible manufacturer representatives for major pieces of equipment. The CMGC shall notify the Commissioning Authority at least 5 days in advance of any equipment start-up, providing the Commissioning Authority a copy of the pre-start sections of the installation and start-up plan at that time.

- c. The Commissioning Authority shall observe installation, start-up and checkout of selected systems. Procedures on the plans and checklists will be spot-checked by the Commissioning Authority prior to testing.
- d. The Trade Subcontractors and vendors shall execute start-up and provide the Commissioning Authority with a signed and dated copy of the completed construction checklists and installation and start-up documentation. The Trade Subcontractors shall clearly note any items that have not been completed and the plan for their completion.
- e. The Trade Subcontractors shall operate each commissioned device or assembly to the full extent of its capability, from minimum to maximum, under automatic and manual control and verify that the equipment, system and assembly is functioning according to the specifications, manufacturer's recommendations and good operating practice.
- f. The Construction Checklist and manufacturer installation and startup check sheets and procedures for a given system shall be successfully completed and submitted prior to formal testing or testing, adjusting, and balancing of the equipment.
- g. Where final balancing of a system or particular components thereof are not specifically indicated to be performed by the University or University's consultants, the CMGC and Trade Subcontractors shall provide final balancing and adjustments for operation within specified tolerances prior to testing and demonstration of such system.
- h. The Trade Subcontractors shall submit installation, startup and checkout documentation prior to testing equipment.
- i. The Commissioning Authority will review installation, startup and checkout documentation and identify incomplete areas.
- j. The Trade Subcontractors shall correct all areas that are deficient or incomplete in the checklists in a timely manner.

### 3.3 PHASED START-UP AND TESTING--CLEAN ROOM

- A. The Project will require start-up and initial checkout to be executed in phases. This phasing will be planned and scheduled in detail in coordination meetings. Results will be added to the master schedule.
  1. The intent of this phasing is to ensure that sufficient chilled and heating water and electrical power (including backups) are confidently available to the systems serving the clean room during successively cleaner clean room stages, without requiring processes that will contaminate the clean room.
  2. This will require that primary equipment (chillers, boilers, clean room air handlers, power and generator) will be started, partially balanced and functionally tested and put into active operation. Then, later as ancillary and secondary portions of the primary equipment are finished and tested, both primary and secondary systems shall be functionally tested as a complete system, with some primary system functions being tested twice.
- B. Any equipment started up or tested which later is modified shall have affected portions or potentially affected portions of equipment, sequences and interlocks retested to ensure that the entire system or assembly functions properly.

### 3.4 TESTING

- A. This sub-section applies to all commissioning testing for all Divisions of the Project Manual.
- B. The Trade Subcontractors shall be responsible to fully test all systems and assemblies according to the Specifications. The Commissioning Authority will direct, witness and document most of the mechanical systems tests. The electrical Trade Subcontractors shall direct and document most electrical component tests with the Commissioning Authority spot witnessing and reviewing completed reports. The Trade Subcontractors shall execute all tests; except at the discretion of the Commissioning Authority, and approval of the Trade Subcontractors, the Commissioning Authority may execute tests of selected equipment. Refer to the Check and Testing Responsibility Table provided as a supplement to this Section for details.

- C. Tests for a given system or assembly shall not be conducted until they are fully operational under normal and reliable control with control calibrations, programming and control system graphics complete and checked out and the Trade Subcontractors have submitted a completed construction checklist and where applicable a startup report, satisfactory to the Commissioning Authority.
- D. Testing Requirements: The testing requirements for specific systems and assemblies are found in other specification sections.
- E. Objectives and Scope:
  - 1. The objective of testing is to demonstrate that each system is operating according to the documented University Objectives and Contract Documents. For dynamic systems, testing facilitates bringing the systems from a state of initial operation to full dynamic operation. For static elements, testing verifies the performance of the assembly in its installed state under conditions specified in the testing requirements. Additionally, during the testing process, areas of deficient performance are identified and corrected.
  - 2. In general, testing shall include testing each sequence in the sequence of operations, and other significant modes, sequences and control strategies not mentioned in the written sequences; including, but not limited to startup, shutdown, unoccupied and manual modes, modulation up and down the unit's range of capacity, power failure, alarms, component staging and backup upon failure, interlocks with other equipment, and sensor and actuator calibrations. All interlocks and interactions between systems shall be tested. All larger equipment will be individually tested. Like units or assemblies that are numerous (many smaller rooftop packaged units, air terminal units, exhaust fans, windows, etc.) may have an appropriate sampling strategy applied. Heating equipment must be tested appropriately during winter and air conditioning equipment must be tested appropriately during summer to demonstrate performance under near-design conditions.
- F. Development of Functional and Performance Test Procedures:
  - 1. Test procedures and documentation forms are not finalized until after equipment and control system submittals and shop drawings are approved. The party responsible for developing, reviewing and approving the procedures is given in Supplement 3 to this Section.
  - 2. The party responsible for writing the test procedures obtains needed documentation which generally includes equipment Specifications, testing requirements, O&M manuals, approved submittals and shop drawings, start-up instructions, sequences of operation, and mechanical, electrical and control drawings and writes detailed step-by-step testing procedures to comply with the testing requirements.
  - 3. Prior to execution, any test procedures developed by the Commissioning Authority are provided to the Trade Subcontractors who shall review the tests for feasibility, safety, equipment and warranty protection.
  - 4. Prior to execution, test forms developed by the Trade Subcontractors are reviewed and approved by the Commissioning Authority.
  - 5. Test procedures shall be written and submitted to reviewers at least 14 days prior to executing the tests.
- G. Test Procedure Format: Three sample test forms for mechanical equipment are provided in Supplement 2 to this Section. The final test procedure forms shall include (but not be limited to) the following information:
  - 1. System and equipment or component name(s).
  - 2. Equipment location and ID number.
  - 3. Unique test ID number and reference to unique construction checklist and start-up documentation ID numbers for the piece of equipment.
  - 4. Date.
  - 5. Project name.
  - 6. Participating parties.
  - 7. A copy of the Specification Section describing the test requirements.
  - 8. A copy of the specific sequence of operations or other specified parameters being verified.
  - 9. Formulas used in any calculations.
  - 10. Required pre-test field measurements.
  - 11. Instructions for setting up the test.
  - 12. Special cautions, alarm limits, etc.
  - 13. Specific step-by-step procedures to execute the test for each sequence or feature being verified, in a clear, sequential and repeatable format. Each must be tailored and applicable to this project.
  - 14. Acceptance criteria of proper performance with a "Yes/No" check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
  - 15. A section for comments.
  - 16. Signatures and date block for the Commissioning Authority.

- H. The Commissioning Authority will review University-contracted, factory testing, required University-witnessed acceptance tests and tests conducted by regulatory authorities which the Commissioning Authority is not responsible to oversee, including documentation format, and will determine what further testing or format changes may be required to comply with the Specifications and rigor desired by the University. Redundancy of testing shall be minimized. Documentation of these tests will be included in the Commissioning Record.
- I. Test and Verification Methods:
1. Testing and verification for most dynamic equipment shall be achieved by an appropriate combination of active testing (persons manipulate the equipment and observe its function) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers. For certain tests documenting with photographs, video or audio recordings may be appropriate. The testing requirements sections of the Specification describe which methods shall be used for each test. The Commissioning Authority may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the University.
  2. Simulated Conditions: Simulating conditions other than by overwriting a value shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.
  3. Overwritten Values: Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable, e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.
  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 overwritten values.
  5. Altering Setpoints: Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55 degrees F, when the outside air temperature is above 55 degrees F, temporarily change the lockout setpoint to be 2 degrees F above the current outside air temperature.
  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 tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during construction checklists and calibrations.
  7. Setup: Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Trade Subcontractors 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 Trade Subcontractors shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.
  8. Sampling: Multiple identical pieces of non-life-safety or otherwise non-critical equipment may be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. The specific recommended sampling rates are specified with the testing requirements. It is noted that no sampling by the Trade Subcontractors is allowed in construction checklist execution.
  9. Testing Order: In general, testing is conducted after construction checklisting and start-up has been satisfactorily completed. The control system is sufficiently tested and approved by the Commissioning Authority before it is used for testing, adjusting and balancing or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before testing of air-related or water-related equipment or systems. Testing generally proceeds from components to sub-systems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is verified.
  10. Trend Logs and Monitoring: Trend logs required in the testing requirements shall be set up and executed by the Trade Subcontractors and provided to and analyzed by the Commissioning Authority. Monitoring using dataloggers will be conducted by the Commissioning Authority. Trend logs and monitoring are conducted after active testing and subsequent trouble-shooting are complete and systems are in normal operation without frequent service shutdowns, etc.

- J. Problem Solving: The burden of problem solving is on the CMGC and Trade Subcontractors and the Architect, though the Commissioning Authority may recommend solutions to problems found.

### 3.5 ISSUES AND NON-CONFORMANCE

#### A. Issue Management

1. The Commissioning Authority will record the results of document reviews, field observations, tests conducted or reviewed and trend logs or monitoring. All deficiencies or non-conformance issues will be recorded on a master Issues Log kept by the Commissioning Authority. The Issues Log will be kept updated by the Commissioning Authority.
2. A current copy of the Issues Log will be provided to the CMGC and University on a regular basis, as requested by the CMGC or University. New issues since the last printing will be explicitly identified.
3. Issues warranting a request for information (RFI) will be forwarded by the Commissioning Authority to the designated party for developing the RFI, or the Commissioning Authority will generate and forward the RFI directly.
4. Issues of non-compliance or items that are incomplete or are requiring Designer input will be sent to the CMGC or Designer and University by the Commissioning Authority via appropriate channels.
5. For some issues it may be unclear whether the issue requires a Designer response prior to action. The Commissioning Authority will in those cases send the issue to either the Designer or to the CMGC or possibly both. If the Designer or CMGC believe it is not their initial responsibility, they shall state this in a reply to the Commissioning Authority within two days of receipt. The Commissioning Authority will forward to the designated party.
6. The Issue Memorandum sent via email to the CMGC or Designer on each issue will include a statement whether the resolution of the issue is holding up or will likely delay a commissioning process and a deadline for a response. Responses can be made by replying to the original email.
7. When completion of a task or other issue has been identified by the Commissioning Authority as holding up or is likely to delay any commissioning process, particularly functional testing, the CMGC or Designer, as applicable, shall be required (as noted in the Issue Memorandum), within two days of notification of the issue, to notify the Commissioning Authority in writing providing the planned actions and an expected date of completion. The CMGC shall notify the Commissioning Authority in writing within one day of completion listing the actions taken to resolve the issue. It is not the responsibility of the Commissioning Authority to obtain this status information through meeting attendance, asking questions or field observation.
8. The Commissioning Authority documents resolutions in the Issues Log and schedules retesting and reinspection as needed.
9. Corrections of minor issues identified may be made during the tests at the discretion of the Commissioning Authority and with the issue and resolution documented in the Issues Log.
10. Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the Commissioning Authority will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the written request of the University.
  - a. Cost of Retesting: Problems identified during testing will fall into the following five categories.
    - 1) Equipment or hardware not installed or not installed properly.
    - 2) Controls program not per the approved sequence of operation (either the specific specified sequence was not programmed, or the methods and subroutines used to meet the specified sequence or performance requirement do not meet the objectives).
    - 3) Air or water balancing does not meet the design documents when the system has the capacity to do so.
    - 4) Specified design control sequences, setpoints or schedules require modification to achieve proper operation or control.
    - 5) Design balancing quantities require modification.
  - b. If a delay occurs because of the case of (1), (2) or (3) in the article immediately above, no additional compensation will be given to the subcontractor involved in troubleshooting, making corrections or retesting.
  - c. If a delay occurs because of the case of either (4) or (5) in the article above, additional compensation may be required depending on how quickly revisions can be made.
  - d. The determination of the cause of the problem will be by agreement between the University, the Architect and design subconsultants, the Commissioning Authority and the CMGC.
  - e. For a deficiency identified, not related to any construction checklist or start-up omission or fault, the following shall apply: The Commissioning Authority will direct, document and evaluate the retesting of up to 10% of the test procedures of the equipment once at no "charge" to the Trade

- Subcontractor or CMGC for their time. However, the Commissioning Authority's time for additional retesting beyond 10% will be charged to the CMGC.
- f. The time for the Commissioning Authority to direct, document and evaluate any retesting required because a specific construction checklist or start-up test item, reported to have been successfully completed, but determined during testing to be faulty, will be charged to the CMGC.
  - g. The CMGC shall reimburse the University and Commissioning Authority for costs when a scheduled test cannot be completed due to:
    - 1) Failure of the CMGC to schedule the test with all parties required to perform the test or with regulatory authorities required to witness the test.
    - 2) Failure of the CMGC to provide required notice for tests that have been cancelled or rescheduled.
    - 3) Failure of the CMGC or Trade Subcontractors to have in place test equipment, support equipment, instrumentation, permits, or other ancillary equipment or systems required for successful execution of the test.
    - 4) Failure of the Trade Subcontractors to complete pre-start or start-up procedures or other work required as a prerequisite for execution of the test.
11. The CMGC shall respond in writing to the Commissioning Authority and University at least as often as commissioning meetings are being scheduled concerning the status of each outstanding issue identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.
12. Any required retesting by the Trade Subcontractors shall not be considered a justified reason for a claim of delay or time extension by the Trade Subcontractors.
- B. Failure Due to Manufacturer Defect: For identical or near-identical components numbering more than 10 (e.g., terminal units, diffusers, traps, valves, etc.). If in the opinion of the University or Designer, 10 percent, or 3, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance Specification, all identical units may be considered unacceptable by the University. In such case, the Trade Subcontractors shall provide the University with the following:
- 1. Within 1 week of notification from the University, the Trade Subcontractors or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the University within 2 weeks of the original notice.
  - 2. Within 2 weeks of the original notification, the Trade Subcontractors or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc., and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the Specification requirements of the original installation.
  - 3. The University will determine whether a replacement of all identical units or a repair is acceptable.
  - 4. Two examples of the proposed solution will be installed by the Trade Subcontractors and the University will be allowed to test the installations for up to 1 week, upon which the University will decide whether to accept the solution.
  - 5. Upon acceptance, the Trade Subcontractors and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within 1 week from when parts can be obtained.
- C. Approval and Acceptance: The Commissioning Authority will note each satisfactorily demonstrated function on the test form. However, formal approval of an entire test form is not normally given. Functional approval or acceptance of a system is indicated after all testing and monitoring is complete and there are no outstanding issues for that equipment or assembly in the Commissioning Authority's Issues Log.

### 3.6 DEFERRED TESTING

- A. Unforeseen Deferred Tests: If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and testing may be delayed upon written approval of the University.
- B. Seasonal Testing: During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in the testing requirements shall be completed as part of this contract. The Commissioning Authority will coordinate this activity. Tests will be executed, documented and deficiencies corrected by the Trade Subcontractors, with facilities staff and the Commissioning Authority witnessing. The

Trade Subcontractors shall make needed final adjustments to the O&M manuals and Record Documents due to the testing results.

### 3.7 DOCUMENTATION

- A. Commissioning Plan: The Commissioning Plan is defined in this Section and follows the process outlined in the Specifications. The Commissioning Authority will develop and update the commissioning plan as construction progresses. The Specifications will take precedence over the Commissioning Plan.
- B. Schedule: The University and CMGC and the Trade Subcontractors shall work with the Commissioning Authority using established protocols to schedule the commissioning activities. The University and CMGC shall integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process. As construction progresses, more detailed commissioning schedules shall be developed. The CMGC shall provide a minimum of 2 weeks notice prior to the date of testing to the University and Commissioning Authority. In addition, the Commissioning Authority and University shall be notified 36 hours in advance when tests are canceled or rescheduled.
- C. Documentation required of the Trade Subcontractors shall consist of the following:
1. Construction checklist form completed.
  2. Startup and initial checkout forms completed.
  3. Completed test forms and record of deficiencies and incomplete items for tests they are responsible to document.
  4. Training record (see Division 01, Section 017900, Demonstration and Training).
  5. Contributions to Systems Manual (flow diagrams, fire alarm and emergency power matrix, seasonal startup and shutdown procedures, red-line drawings).
- D. Reporting and Documentation by the Commissioning Authority:
1. The Commissioning Authority will provide regular reports of all issues and progress directly to the University with increasing frequency as construction and commissioning progresses. Issues that are in the schedule critical path or which significantly affect budget or building performance will be reported within 2 days of identification.
  2. The Commissioning Authority will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.
  3. The Commissioning Authority will witness and document the results of all functional and performance tests using the specific procedural forms developed for that purpose. The Commissioning Authority will include the filled out forms in the Commissioning Record.
  4. Systems Manual: A Systems Manual will be compiled by the Commissioning Authority. See details in this Section.
  5. Commissioning Record: The Commissioning Authority is responsible to compile, organize and index commissioning data by equipment and assembly into labeled, indexed and tabbed, three-ring binders and deliver it to the University, to be included with the O&M manuals. Three copies of the manuals will be provided. The record will contain for all systems and assemblies together the Summary Report, Issues Log, Commissioning Plan, progress reports, submittal reviews, O&M manual reviews, summary training record, Design Record, testing schedule. Then for each system or assembly the sequence of operation, construction checklist, start-up report, test record, training record, and the indexed and fully labeled trend log analysis of all systems. Included in the record will be all outstanding non-compliance items 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 test, inspection, trend log, etc. where the deficiency is documented.
  6. Summary Report: The summary commissioning report will include 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 or assembly, the report will contain the disposition of the Commissioning Authority regarding the adequacy of the equipment, documentation and training meeting the Contract Documents in the following areas: 1) installation, including equipment meeting the equipment Specifications, 2) functional performance and efficiency, 3) equipment O&M manual documentation, and 4) operator training. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. will also be listed. Each non-compliance issue will be referenced to the specific test, inspection, trend log, etc. where the deficiency

is documented. The functional performance and efficiency section for each piece of equipment will include a brief description of the verification method used (active testing, FMCS trend logs, data loggers, etc.) and include observations and conclusions from the testing.

- E. Systems Manual: The Commissioning Authority (CA) will compile a Systems Manual. The following components of the manual are organized and indexed by system into one compilation. The responsibility of the Trade Subcontractors and other parties in the System Manual development are given in brackets.
1. Design Record: The Design Record for each system or assembly included in the Systems Manual, consists of:
    - a. University Requirements and Objectives (see Definitions). [By Architect.]
    - b. Design Basis (see Definitions). [By Architect.]
    - c. Design Narrative (see Definitions). [By Architect.]
    - d. Performance Metrics/Benchmarks, if developed (see Definitions). [By CA, if in scope.]
  2. Fire and life safety and emergency power criteria including a general strategy narrative, detailed sequences and an HVAC fire and emergency power response matrix. [Format by CA and content by Trade Subcontractors and Architect.]
  3. Flow Diagrams: Include reductions of the flow or one-line diagrams from the drawings for all commissioned systems for which flow drawings exist. [By Trade Subcontractors]
  4. Seasonal start-up and shutdown, manual and restart operation procedures. [By Trade Subcontractors.]
  5. Complete as-built Control Drawings with points list, valve schedules, schematics, control system architecture and full sequences of operation (see example sequence of operation for rigor and format as a supplement to this Section). [By Trade Subcontractors.]
  6. A description of and rationale for all energy and water saving features and strategies with operating instructions and caveats about their function and maintenance relative to energy use. [By CA.]
  7. Recommendations for recalibration frequency of sensors and actuators by type and use. [By CA.]
  8. Plans for continuous commissioning or recommended frequency for recommissioning by equipment type with reference to tests conducted during initial commissioning. [By CA.]
  9. Description of the primary recommended standard trend logs in the control system that will assist in maintaining comfort, energy efficiency and system control. This will include sample plots with explanations of what to look for in the graphs. [By CA.]
  10. Specific recommendations regarding seasonal operational issues that affect energy use. [By CA.]
  11. A list of all user adjustable setpoints and reset schedules with a discussion of the purpose of each and the range of reasonable adjustments with energy implications. Include a schedule frequency to review the various setpoints and reset schedules to ensure they are at current relevant and efficient values. [By CA.]
  12. A list of time of day schedules [by Trade Subcontractors] and a schedule frequency to review them for relevance and efficiency [by CA].
  13. Guidelines for establishing and tracking benchmarks for whole building energy use and primary plant equipment efficiencies. [By CA.]
  14. Guidelines for ensuring that future renovations and equipment upgrades won't result in decreased energy efficiency and maintaining the final design intent. [By CA.]
  15. A list of diagnostic tools, with a description of their use, that will assist facility staff in operating equipment more efficiently. [By CA.]
    - a. Troubleshooting table for ongoing achievement of the University's project requirements and system performance [By CA].
    - b. Systems to be included in the Systems Manual: All the systems listed in this Section as being commissioned.
- F. O&M Documentation Completion and Review:
1. The Commissioning Authority will provide an O&M Manual Checklist that lists the elements of the manuals required by the specifications. The Trade Subcontractors shall fill out this checklist for each manual and submit with the manual.
  2. Prior to substantial completion, the Commissioning Authority shall review the O&M manuals for systems that were commissioned to verify compliance with the Specifications. This verification will be conducted by sampling the manuals against the O&M Manual Checklist. The Commissioning Authority will communicate deficiencies in the manuals to the University and the Architect. If systemic deficiencies are found, the Trade Subcontractors shall go back through those checklist items on every manual and verify compliance.
  3. Upon a successful review of the corrections, the Commissioning Authority will recommend approval and acceptance of these sections of the O&M manuals.
  4. The Commissioning Authority will also review each equipment warranty and verify that all requirements to keep the warranty valid are clearly stated.

5. This work does not supersede the Architect's review of the O&M manuals.

G. Summary of Written Work Products: Written work products generated as part of the commissioning process are described in various parts of the Specifications and in the Commissioning Plan. In summary, the written products are:

	Product	Developed By
1.	University requirements and objectives	Architect per University Project Design Requirements
2.	Design narratives and design basis	Architect
3.	Final commissioning plan	Commissioning Authority
4.	Commissioning meeting minutes	Commissioning Authority
5.	Commissioning schedules	University and CMGC with input from the Commissioning Authority
6.	Special equipment/assembly submittals	Trade Subcontractors
7.	Sequence clarifications	Trade Subcontractors and Architect, as needed
8.	Construction checklist forms	Trade Subcontractors
9.	Start-up and initial checkout plan	Trade Subcontractors with review by Commissioning Authority
10.	Construction checklists, start-up and initial checkout forms	Filled out by Trade Subcontractors
11.	Emergency power and fire alarm response matrix.	Format by Commissioning Authority and content by Trade Subcontractors and Architect
12.	Issues Log	Commissioning Authority
13.	Commissioning Progress Record	Commissioning Authority
14.	Test forms	Commissioning Authority and Trade Subcontractors
15.	Filled out tests	Commissioning Authority and Trade Subcontractors
16.	Commissioning Record	Commissioning Authority
17.	Overall training plan	Trade Subcontractor for review by Commissioning Authority and University
18.	Specific training agendas and record	Commissioning Authority and Trade Subcontractors
19.	Systems Manual	Commissioning Authority

### 3.8 TRAINING OF UNIVERSITY PERSONNEL

A. The Trade Subcontractors are responsible to provide training for University personnel per the Contract Documents. The Trade Subcontractors shall work with the Commissioning Authority to develop appropriate training and orientation agendas for equipment and assemblies and provide skilled trainers for the sessions. The Commissioning Authority will ensure that the Trade Subcontractors execute training per the Contract Documents and will provide a brief system overview at the beginning of the training sessions for the primary equipment. The training program is described in Division 01, Section 017900, Demonstration and Training.

3.9 STATIC ELEMENTS COMMISSIONING

- A. The following tasks constitute the commissioning of the listed LEED static elements.
- B. Water Use Reduction Credit 3. Static features (shower and faucet aerators, low flow fixtures, etc.) will have submittals reviewed by the University to verify that they meet the specified LEED standards. The Commissioning Authority verifies that submittals were approved by the University or Architect. The University or Architect performs site observation to ensure that submitted products were installed properly.
- C. Energy and Atmosphere Features. The static energy features (wall, roof and pipe insulation, and the envelope assembly, including windows and doors) for the energy Credit 1 will have submittals reviewed for compliance with the specifications by the Architect. The Commissioning Authority verifies that submittals were approved by the University or Architect. The University or Architect performs site observation to ensure that submitted products were installed properly according to good thermal practice for air and water leakage potential.
- D. IAQ management plan (Credit 3.1 and 3.2) features (IAQ management plan and building flush-out): Not explicitly required to be commissioned in LEED, but for this project the Commissioning Authority will review the CMGC's submittal of means and methods of the plan and ensure that a party has been assigned responsibility by the CMGC to monitor compliance with the plan.
- E. Indoor chemical and pollutant source control (Credit 5) features. Entry-way systems, isolation and ventilation of house-keeping rooms, copy rooms and other chemical containing spaces and plumbing systems serving chemical mixing will receive on-site observations by the Commissioning Authority to verify that specified and submitted features are installed and operating properly. The isolation rooms or rooms with required differential pressures will be verified through testing when specified in Division 01, Section 013513.13, Cleanroom Certification and Acceptance.
- F. Envelope air and moisture control design and integrity. Differential pressures will be measured between inside and outside to ensure the building is positively pressurized at the envelope. See test requirements in Division 01, Section 013513.13, Cleanroom Certification and Acceptance.

3.10 SUPPLEMENTS

- A. The supplements listed below, and attached following "END OF SECTION," are a part of this Specification:
  - 1. Supplement 1- Representative Construction Checklist
  - 2. Supplement 2-Sample Tests
  - 3. Supplement 3- Check & Testing Responsibility Tables
  - 4. Supplement 4- Sample Sequence of Operation

END OF SECTION 019113