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	Engineering and Design SYSTEMS COMMISSIONING PROCEDURES	
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Regulation
No. 1110-345-723

31 July 1995

Engineering and Design
SYSTEMS COMMISSIONING PROCEDURES

1. Purpose. This regulation provides policy and guidance for developing systems commissioning procedures and executing systems commissioning acceptance testing to verify that the construction requirements are met and ensure that systems operate as indicated in the plans and specifications, especially regarding sequences of operation.

2. Applicability. This regulation applies to all HQUSACE/OCE elements, major subordinate commands, districts, and field operating activities (FOA) having military and/or support for others design and construction responsibilities.

3. References.

a. ANSI/ASHRAE GUIDELINE 1-1989, Guideline for Commissioning of HVAC Systems.

b. AR 415-15, Military Construction Army Program Development.

c. ER 5-7-1 (FR), Project Management

d. ER 25-345-1, Systems Operation and Maintenance Documentation.

e. ER 415-1-10, Contractor Submittal Procedures

f. ER 415-1-11, Biddability, Constructibility, Operability, and Environmental Review.

4. Background. Designers must effectively convey the design*s intended operation into the plans and specifications. Systems commissioning performed to verify the design intent, as expressed in the plans and specifications, is a necessary element for true beneficial use of any project. Several forms of testing, operation and demonstration are contained in the various technical sections of construction contract documents. These requirements evolve from guide specifications and national standards. Typically, operational testing is limited to individual equipment and/or small subsystems specified within the specific technical section. There is a lack of a concentrated requirement for large, interdisciplinary systems testing,

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operation and demonstration. Testing of system elements and interactions, beyond the individual technical sections, is often needed. Such a concentrated requirement to verify that systems operate as indicated in the plans and specifications, especially regarding sequences of operation is a significant contributor to customer satisfaction with the entire design and construction process. Operation and maintenance functions are enhanced when all of the responsible parties are cognizant of contract compliance, construction quality, and performance and operational parameters of the systems. The importance for a disciplined approach to systems commissioning is intensified as the cost, complexity, uniqueness, and magnitude of the project, system or process involved increases. The need is further intensified by the interdisciplinary interactions of the various systems comprising the entire project. The concept and practice of systems commissioning has long been recognized in the acceptance of industrial processes, nuclear technology, aviation technology, and similarly complex projects. The heating, ventilating, and air conditioning (HVAC) industry has recognized a need to formulate procedures for functional performance testing and documentation of HVAC systems. ANSI/ASHRAE GUIDELINE 1-1989, Guideline for Commissioning of HVAC Systems provides procedures and methods for verifying and documenting the actual performance of HVAC systems and evaluating their conformity with the design intent.

5. Guidance.

a. The need for systems commissioning, beyond normal construction contract requirements, must be established early in the planning/design process. The determination shall be made on a project specific basis. Early establishment of the need will allow the necessary planning and design resources to be identified and programmed. Systems commissioning represents a service which can be provided on projects. The service maximizes the opportunity for successful O&M. The value of the service to the using agency is proportional to the user's participation. The using agency's participation is presented herein so that appropriate Corps elements can fully understand when and how the user is to participate to maximize the value of the commissioning process. When systems commissioning is being executed, the using agency is to be notified, encouraged, and expected to participate. Occasions may arise when the using agency will not be available to participate. In these instances, the process of commissioning should continue without causing delays to contract performance. As a minimum, the using agency, design agent and construction agent will all actively participate in identifying and developing system commissioning requirements. Optimally, the need for systems commissioning shall be identified in the project's scope of work (SOW). In the event that systems

commissioning requirements materialize less than optimally, the procedures established in AR 415-15 shall be followed to properly identify and program the necessary planning and design resources and construction funding requirements.

(1) The using agency or other associated organizational elements (e.g., Installation, DEH, MACON, etc.) shall identify and substantiate any need for systems commissioning and the associated construction cost on the DD Form 1391, Military Construction Project Data, during project development. In the case of work for others, a Memorandum of Understanding (MOU) or the particular SOW governing the work shall describe the concept of systems commissioning.

(2) The design agent or other associated organizational element (e.g., HQUSACE, MSC) may identify, validate, and substantiate any need for systems commissioning and the associated construction cost during the review stage of the project development process, including review of DD Form 1391. This identification shall also occur where the design agent develops the 1391 as a support service to the using agency. In the case of work for others, the design agent shall ensure that the MOU or SOW requires that systems commissioning be identified on a project specific basis, and for the design agent to recommend systems commissioning during development of the design SOW.

(3) The construction agent or associated organizational element (e.g., HQUSACE, MSC) may identify and substantiate any need for systems commissioning during participation in the design process as described in ER 415-1-11.

(4) In the event a need for systems commissioning is identified by elements outside the using agency, its application and any cost or schedule implications must be coordinated and approved by the using agency.

b. Systems commissioning represents testing, operation and demonstration efforts to verify the intended design as reflected in the contract documents has been achieved in the installed construction. Systems commissioning extends beyond the testing, operation and demonstration associated with individual technical contract requirements typically identified in individual specification sections. Systems commissioning requirements as described herein are not appropriate for all projects or systems. Projects or systems exhibiting at least two of the following characteristics shall be considered as prime candidates for systems commissioning as described herein:

(1) Process oriented – The project or system involves a

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continuous operation or treatment beginning with an expected input or load condition and resulting in an established continuous output or condition.

(2) Large - The expected construction value of the project or system exceeds \$10 M if new construction is proposed, or \$5 M if renovation, rehabilitation, or alteration is proposed. In applying this characteristic, the extent to which similar, but smaller portions are essentially repeated, shall be considered.

(3) Complex - The project or system is expected to consist of intricately combined and interactive portions, the whole of which has difficult to understand, analyze, or evaluate performance characteristics.

(4) Unique - The project or system involves technology or specific equipment which is one of a kind and, excluding prototypes and pilot operations, not more than one other beneficially proven example exists.

(5) Significant consequential magnitude - The project or system is critical to life safety, the mission of the installation, or environmental quality. Failure of the project or system to function as designed will result in a profound degradation of these critical features.

(6) Requires systems operation and maintenance documentation - The project or system has been identified as described in ER 25-345-1 and requires systems operation and maintenance documentation, shared as a two-step operation by the designer and the construction contractor. Systems commissioning is a natural corollary to systems operation and maintenance documentation. It should be rare that the need for either would exist without the other.

6. Action to be taken. Whenever the need for systems commissioning is identified and the appropriate resources authorized, the using agency, design agent, and construction agent shall all actively participate as a team during the design and construction process as outlined below. The particular resources, processes, and responsibilities shall be documented in the Project Management Plan (PMP) that is specifically developed for that project. Minimum requirements of a PMP are described in ER 5-7-1 (FR). It is expected that the using agency will fund the participation of its own personnel in the commissioning activities. For Corps of Engineers costs associated with commissioning, funding shall be in accordance with the activities performed. For design activities occurring prior to award of the construction contract, appropriate Planning and Design (P&D)

funds shall be utilized. For activities occurring after construction contract award, design agent commissioning activities shall be related to extension of design and will therefore be funded by Engineering During Construction (EDC) resources. Construction agent activities shall be funded with Supervision and Administration (S&A) resources. Design agent quality assurance support shall be available to and under the control of the construction agent. QA support would be S&A funded. Construction contractor activities associated with executing the commissioning process during construction must be included as contract requirements and therefore would be funded with project construction funds.

a. The district, in its capacity as design agent, shall ensure that the design SOW requires the design services necessary to develop a contract specification section(s) using the guidelines in Appendix A and, as outlined in Appendix B. The district shall ensure that systems commissioning requirements included in the construction contract will result in verification of the design intent, as expressed in the plans and specifications with the installed construction. The designer will document the design intent for all systems requiring commissioning as part of the commissioning requirements of the contract. Districts shall ensure appropriate participation by the designer after award and during execution of the systems commissioning requirements. District Quality Management Programs shall document the assurance procedures to be used to verify compliance with these requirements. The district shall secure documentation indicating the satisfaction of the using agency and construction agent with the systems commissioning requirements developed prior to bid opening. The review and certification processes established by ER 415-1-11 will serve to document both the construction agent*s and the using agency*s satisfaction with the systems commissioning requirements developed prior to bid opening.

b. The district, in its capacity as construction agent, shall ensure that the construction contractor provides all necessary labor, services and materials to perform and document the systems commissioning requirements. District Quality Assurance Programs shall document the procedures to be used to verify compliance with these requirements. During construction, the Administrative Contracting Officer (ACO) will act as the chairperson of the Commissioning Team.

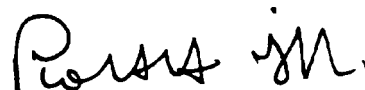
c. The using agency, in its capacity as user/owner/operator and ultimate customer, should make a continuous corporate commitment to the systems commissioning process. The using agency*s participation begins early in project development and requires continuous representation through the

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design/construction process. Appropriate resources and representation must be programmed and provided as required in the commissioning process. While the Corps of Engineers is ultimately responsible for a fully functional project, the using agency should convey their commissioning concerns and functional requirements clearly and early on a project specific basis, and participate in witnessing and determining acceptability of commissioning results. The design/construction elements and the using agency should work together in developing realistic and reasonable systems commissioning requirements to ensure adequate and complete results, and recognize the cost and schedule consequences associated with idealistic requirements.

d. Acceptance of the systems commissioning process, and the completed construction, may require extrapolation or interpretation of systems commissioning results to conditions other than those experienced during actual execution. Normally, an acceptable characteristic will be determined as a consensus of the commissioning team comprised of the using agency, design agent and construction agent. During construction, the ACO may need to facilitate and mediate to establish a consensus. If acceptable performance cannot be achieved, the necessary corrective measures should be carried out. The ACO will identify the construction deficiencies and/or design deficiencies causing problems and pursue a course of corrective action. The designer may be used to assist in diagnosing the cause of problems and should always provide recommended solutions to design deficiencies. The solutions to significant problems should be approved by the commissioning team, including the user. If the user cannot respond in a timely manner, decisions must be made without user input. Needless contract delays cannot be tolerated. The ACO must issue appropriate directions for corrective measures, through proper contractual channels. In cases of contractual disputes the appropriate contracting officer shall determine final direction.

FOR THE COMMANDER:



2 Appendices
APP A - Guidelines for the
Commissioning Process
APP B - Outline for the
Preparation of Systems
Commissioning Specification

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APPENDIX A

GUIDELINES FOR THE COMMISSIONING PROCESS

1. PURPOSE AND SCOPE

a. Purpose

(1) These guidelines provide procedures and methods for documenting and verifying the performance of systems provided in Corps of Engineers construction projects so that systems operate in conformity with the design intent.

(2) The guidelines are intended to formulate procedures for:

(a) The documentation of occupancy requirements and design assumptions for each system and the project as a whole.

(b) The documentation of the design intent for use by contractors, users and O&M staff.

(c) Functional performance testing and documentation necessary for evaluating both the individual systems and the interrelated performance of the project systems for acceptance.

(d) Adjusting the systems to meet actual occupancy needs within the capability of each individual system and the interrelated performance of all systems.

b. Scope

(1) The guidelines are applicable to all types of systems in construction projects.

(2) The guidelines establish methodology for:

(a) Identifying roles of all parties involved in the commissioning process.

(b) Verifying and documenting the actual performance of systems.

(3) The guidelines are not normally intended to be used for the evaluation of system application or for verification of energy-efficient operation. Energy efficiency ratings are produced under controlled laboratory test conditions and cannot be duplicated in the field without significant cost.

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(4) The total commissioning process is necessarily iterative. Deficiencies in one individual system may impact the commissioning of other individual systems as well as the commissioning of the complete project. Deficiencies must be rapidly resolved by the appropriate parties to permit timely completion of the commissioning process.

2. UTILIZATION

a. These guidelines are intended for use by all members of the design, construction and operation team -- the user agency planners, mission and O&M staff; Corps project management, design and construction staff and if applicable, the Architect-Engineer. Support and information will be necessary from the contractor, suppliers and others as may be applicable to a given project. The commissioning process extends through all phases of the project, from authorization through occupancy.

b. The end result should be fully functional and coordinated project systems.

3. DEFINITIONS

a. Acceptable Performance: A component or system being able to meet properly developed and specified design parameters under actual load and/or other properly developed simulated operating conditions. Commissioning goes beyond the normal quality assurance role of ensuring contract compliance, by identifying and correcting design and construction defects which are revealed only by the commissioning procedures.

b. Commissioning Plan: The overall document, usually prepared by the designer for the commissioning team, which outlines the organization, scheduling, allocation of resources, documentation, etc., pertaining to the overall commissioning process. The commissioning plan must be included in the contract documents to specify the contractor*s performance responsibilities. This plan shall be included as part of the Corps overall Project Management Plan for executing the specific project.

c. Commissioning Procedures: The overall document, usually prepared by the contractor for the commissioning team, which outlines the organization, scheduling, allocation of resources, instrumentation, operating parameters, test tap locations, qualifications of testing personnel, performance criteria,

documentation, etc. required to perform the functional performance testing in accordance with the commissioning plan.

d. Commissioning Team: The qualified persons that will plan and carry out the overall commissioning process. The team is composed of designers (Corps and/or Architect-Engineers), users (facility, tenant, O&M) and the administrative contracting officer (ACO) for the construction contract (representing Corps construction). The individual participants on the team may change as the design and construction process proceeds. Participation by the user is not mandatory, but the value of this service to the customer is directly proportional to their participation. The team is supported by the contractor (including appropriate subcontractors, suppliers and manufacturers). The Corps technical manager is the facilitator and mediator for the team during the design phases. During design, the Architect-Engineer or in-house designers will prepare commissioning plans for approval of the team. The ACO for the construction contract is the team facilitator/mediator during the construction phase. In this phase, the contractor will finalize the commissioning plans to make them equipment specific and to match as-built conditions. The contractor will also perform the actual commissioning procedures for approval of the team. It is critical that the numerous commissioning responsibilities of the A-E and contractor are clearly identified in their respective contracts. If necessary, the commissioning team should recommend to the appropriate contracting officer (design or construction) that contract modifications be prepared. If the commissioning team is unable to reach consensus on a particular issue, the situation must be promptly resolved by the active facilitator/mediator. Contractual disputes must receive final resolution by the appropriate contracting officer.

e. Designer: The Architect-Engineer or Corps in-house design group responsible for the design and preparation of contract documents for the construction project.

f. Functional Performance Testing: That full range of checks and tests carried out to determine if all components, subsystems, systems, and interfaces between systems function in accordance with the design intent, as identified in the contract documents. In this context, "function" includes all modes and sequences of control and operation, all interlocks and conditional control responses, and all specified responses to abnormal emergency conditions.

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g. User: The organizational groups that combine to provide facilities, perform facility operation and maintenance and perform actual missions at Corps construction project sites. For Army construction this includes the major command, the installation, the Directorate of Engineering and Housing and the Tenant.

4. AUTHORIZATION PHASE: The user should identify commissioning requirements in the DD 1391 package. Anticipated systems within the project should be identified. Commissioning may be designated for any or all of these systems. Corps district offices may use their vast construction expertise to assist the user in preparation of the DD 1391. When appropriate for a project, MSCs should discuss the need for commissioning through the DD 1391 review process. The preparer should identify the additional cost for construction in the DD 1391 documentation. The added contract cost should be reflected in higher per unit costs for the line items containing the systems which are to be commissioned. Separate construction line items for commissioning should be avoided. As a consequence of the higher contract cost, additional funds will be available for design and contract administration. If design costs above the standard level are anticipated, the additional P&D costs shall be identified by the MSC, along with any other special design instructions developed during the DD 1391 review process. This will alert Programs Management Division (CEMP-M) at HQUSACE of the need to provide additional P&D funds in the design directive. The district office shall identify the construction contract cost and time impacts for commissioning and incorporate them in the ENG Form 3086 estimate.

5. DESIGNER SELECTION PHASE

a. Corps design staff and the user must meet to identify the systems expertise required of the designer, before A-E selection takes place.

b. Corps design staff must identify the requirements for systems expertise and commissioning experience in the selection criteria and the Construction Business Daily (CBD) announcement. The responsibilities of the designer throughout the commissioning process must be highlighted.

c. Select a qualified designer.

6. PRE-DESIGN PHASE

a. Pre-design considerations are as follows. Note that when a code 1 (pre-design) is not provided, these activities must be accomplished in the design phase (code 2):

(1) To set commissioning parameters, responsibilities and documentation during all phases; ensure that project team members are made aware of these requirements; and set a framework for commissioning during all phases.

(2) Document the base information and design intent from which to develop the benchmarks for evaluation of the final performance including: occupancy requirements; design assumptions, building loads/zoning, and system utilization; water and waste water processes; solid waste processing; evaluation criteria for areas of intersystem operation and cost consideration and design compromises.

b. Participants. This phase will involve the user, the Corps district office project managers, construction personnel and designers and if applicable, the Architect-Engineer. The Corps project management element will be involved in the development of the overall project management plan (PMP) which will baseline the scope, schedules, quality, and budgets. This will include documenting all district commitments to and from the using agency.

c. Pre-Design Commissioning Procedure

(1) Define roles and responsibilities of the design and construction team during all phases of commissioning. Assure that each participant has committed sufficient resources for the commissioning process and that contract time and funding allocations are consistent with the commissioning intent. The Corps Project Management element will be involved in the development of the overall PMP which will baseline the scope, schedule, quality, and budgets, including documenting all district commitments to and from the using agency.

(2) Review the facility program. The program should include information regarding facility population, required physical areas for activities and equipment or other special needs, environmental requirements of each system, and budget constraints for the proposed facility.

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d. Definition of requirements. Define the systems requirements for each occupancy, activity and/or physical area of the proposed facility with reference to project criteria and objectives.

e. System Design Concepts

(1) Develop conceptual designs for each system fulfilling requirements of facility objectives. Address areas of intersystem operation and dependency in the concept design.

(2) Define space requirements for equipment.

f. Documentation

(1) Prepare documentation of roles and responsibilities of all parties during all phases of the commissioning process.

(2) Prepare written report defining design assumptions and performance standards of proposed systems, most appropriate conceptual approach and spatial requirements of the systems.

7. DESIGN PHASE

a. Introduction. The objective of this phase of commissioning is to outline the scope of design requirements for each system whose performance is to be verified, with a comprehensive commissioning process. This phase is performed by the Architect-Engineer (or Corps in-house designer) with input from the user and review by Corps engineering and construction elements. The resulting commissioning requirements are to meet the user*s satisfaction.

b. Scope of the Design Phase. The design documents should include detailed requirements for commissioning as follows:

(1) Design criteria and assumptions.

(2) Description of each item of equipment, each system and subsystem, and the intended operation and expected performance at each level. Identify all conditions, especially local conditions, which affect system performance.

(3) Commissioning plan.

(4) Documentation requirements.

(5) Verification procedures. Considerable thought must be given to adequacy of verification (testing) procedures and location of instrumentation to give meaningful results. It may be appropriate to permanently install some or all test equipment for future use by the O&M staff.

(6) Commissioning documentation.

(7) Operation and performance.

c. Design Criteria. Design criteria and assumptions should include appropriate specific design conditions for each space. In addition, the following general considerations should be specifically addressed.

(1) Code and permit requirements and impact on criteria.

(2) Noise and vibration criteria.

(3) Fire protection and life safety.

(4) Maintainability.

d. Description of Systems

(1) The description of each system and its intended operation and performance should include design intent, system and intersystem assumptions, and facility occupancy and utilization.

(2) The description of the system should include basic system type, major components, interrelation of components, capacity and sizing criteria, control systems and sequence of operation, including intersystem operations. If the system's complexity warrants, diagrams should be included for each mode of operation, indicating specific component function and status.

(3) The operation and performance data should include equipment selection and redundancy or backup criteria, intended operation under all potential load or operational scenarios, operation of system components in life safety modes, energy conservation procedures and any other engineered operational mode of the system.

e. Commissioning Plans

(1) The commissioning plan is produced by the designer. It must detail the implementation of the commissioning process. It should include the requirements that each party involved in the commissioning process will have to accomplish, including: sequence, scheduling, cost estimate, documentation requirements, verification procedures (including methods of measurement), staffing requirements, etc.

(2) The parties involved at various stages of the commissioning process will include the user, designers, contractors, commissioning team, manufacturers, and other parties as required.

(3) The needed staffing skills and qualifications shall be specified for the following groups:

(a) Commissioning team. In its capacity as contract quality control representative, the contractor must provide quality control specialists knowledgeable of the various systems being commissioned. The requirement for and qualifications of these QC specialists must be included in the contract documents.

(b) Operation and maintenance teams.

f. Documentation Requirements

(1) The documentation requirements for each party involved in the commissioning process shall be detailed in the contract documents, prepared by the designer. This documentation will be further detailed and submitted by the contractor for approval during the construction phase.

(2) The contract documents shall contain commissioning process requirements which include the following:

(a) Detailed verification procedures for the tests to be performed by each party in the commissioning process. Detailed procedures for intersystem testing to be performed cooperatively by multiple parties. At the end of the process, every mode of systems operation, all system equipment, components and zones and every item in the control sequence description should have been proved operational under all normal operational modes, including part and full load and under abnormal or emergency conditions. This must include every individual interlock and conditional control logic. Temporary upsets of systems, such as distribution fault, control loss, setpoint change, equilibrium upset, and

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component failure, should be imposed at different operating loads to determine system stability and recovery time. The procedures must anticipate scenarios which cannot be performed naturally due to such factors as lack of load or seasonal conditions. Methods of simulation must be described in great detail. Although not desirable, it may sometimes be necessary and acceptable to postpone testing, pending the appropriate climatic conditions, provided all parties understand the contractual implications.

(b) Detailed checklists for performance testing.

(c) Report forms that will be used to submit test data and results.

(d) Calibration data for test equipment.

(e) Sequence and schedule of procedures. Requirements for incorporation of all commissioning activities in the contractors schedule.

g. Commissioning documentation should be prepared and submitted to the commissioning team at the completion of the commissioning process. The contracts for the Architect-Engineer and the construction contractor must contain those documentation requirements to be performed by each of them. This documentation should include readiness, start-up and performance checklists of the commissioning plan with actual results achieved. Items 1 thru 6 below shall be provided by the construction contractor. Item 7 shall be provided by the designer.

(1) Tests, corrective action and adjusting, retesting.

(2) Operational performance verification tests of all equipment.

(3) Control schematics, performance reports and checklists for verification of the total system and subsystems.

(4) Operating data to include all necessary instructions to the owners maintenance and operation staff in order to operate the system to specified standards.

(5) Maintenance data to include all necessary information required to maintain all equipment in continuous operation.

(6) As-built documents for the systems to include all equipment, components and controls.

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(7) The operation and maintenance manual must address simultaneous operation and maintenance of all the building systems and must specifically consider all intersystem relationships and impacts.

h. Operation and Performance. The schedules for the participation of the operations and maintenance personnel during the construction phase and the subsequent phases of the commissioning process.

8. CONSTRUCTION PHASE

a. Introduction

(1) This section describes the commissioning process during the construction phase of the project. In this phase, the systems are installed, tested and put into operation. When construction is essentially completed, the systems are ready for functional performance testing.

(2) Commissioning is an ongoing process. It continues through the installation of the systems. In this phase, the contractor shall perform all tests of the piping, ducts, wiring and other subsystems and shall perform all start-up, testing, adjusting and calibration activities, as contractually required. The commissioning team, acting through the ACO, shall have the opportunity to witness any or all commissioning activities as part of the contractual quality assurance program. Various members of the commissioning team will normally have specific tests which are of particular interest to their group. Some systems may have contractual requirements for joint witnessing of particular activities.

(3) An important part of the commissioning process is the training of the operations and maintenance personnel. These people should be available at the site during construction to observe the installation of the systems and to learn about their operation. The commissioning team shall assure that the contractor performs this training in accordance with the construction contract.

b. Procedure. Each system operation description must be updated to incorporate design changes that occur prior to or during the construction phase. This information then must be combined with the equipment maintenance data and equipment submittals, including performance data, to form one complete

operations and maintenance manual for training and subsequent use of the operations and maintenance staff.

c. Operation. During critical points of the construction phase, the facility operations and maintenance staff should be available at the site for the purpose of observing construction, especially during equipment installations. This is an opportunity for the user to gain familiarity with the facility systems, but is not to delay the construction process.

d. Submittals

(1) Submittals must be reviewed prior to construction, in accordance with ER 415-1-10, Contractor Submittal Procedures. The construction schedule submittal is of particular importance. It must provide sufficient time near the end of the contract for the various commissioning activities, including adjustments, corrective actions and retesting. Shop drawings, equipment catalog cuts and details, testing procedures, the commissioning plan and commissioning documentation format are also critical submittals.

(a) Equipment submittals should include complete performance data for each piece of equipment -- capacity, flow rates, velocity, pressure losses, horsepower, motor speed (rpm), electrical data, etc. Submittals should also describe testing procedures used to verify performance. After review of equipment submittals, the equipment operations and maintenance information (including parts lists, installation instructions and special tool needs) should be submitted in accordance with specifications requirements.

(b) Because of the importance of the control systems to the proper operation of systems, control submittals should be carefully reviewed to ensure they include all information needed by the operations and maintenance staff to keep the control systems adjusted and calibrated. Information should include the following.

- A fully labeled control piping, wiring or fiber optic schematic, which shows point-to-point piping, wiring or cable and includes all performance parameters such as setpoints, throttling ranges, actions, spans, proportional bands and other control component adjustment or setting data. Locations of pneumatic test ports, electronic system terminal strips or fiber optic terminals and equipment should be indicated on the schematic drawings.

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- Fully labeled elementary electrical ladder diagrams.

- Sequence of operation (narrative description of control system functions) cross-referenced to the control schematics and elementary electrical ladder diagrams.

- Specification sheets for each control component.

(c) The commissioning plan should be prepared following the format described in the contract specifications. It should detail how the commissioning process will be organized, scheduled and documented to include the following items.

- The organization of the commissioning team (Corps design and construction personnel; A-E; testing specialists; contractors, vendors and manufacturers; User*s operations and maintenance staff, etc.)

- A list of activities required to commission the subsystems and systems and the functions of each member of the commissioning team.

- A logical sequence schedule for each commissioning activity coordinated with all members of the commissioning team.

- Commissioning plan documentation forms for all components and systems submitted.

(2) The procedures for testing should be performed in accordance with the contract requirements, as detailed in the commissioning plan.

e. Construction Phase Activities

(1) Quality control compliance testing, adjusting and balancing work must be performed prior to functional performance testing. Operational tests should also be conducted on equipment, duct, pipe, conductors and control systems to verify that mechanical and electrical characteristics meet design requirements.

(2) Controls testing and calibration should begin before or concurrent with, and be completed subsequent to, the systems testing. Testing should include all possible operating conditions and ranges of devices.

(3) The commissioning team shall have the opportunity to witness any or all start-up, testing, balancing and calibration activities which are performed as part of the contractual quality assurance program.

f. Documentation

(1) Controls testing should be accomplished on each control device. All system interlocks, interconnections and safety devices should be checked for proper function.

(2) All control devices should be adjusted and calibrated. All control settings should be verified by comparing actual input and output values to calculated values.

(3) All testing, adjusting and balancing work should be substantially complete with reports submitted and approved prior to the verification and acceptance phase.

(4) Training, warranty, special tools and spare parts should be taken into account under the construction phase.

(5) Contractor and equipment warranties shall be verified.

(6) Special tools and spare parts list shall be verified.

9. ACCEPTANCE PROCEDURES

a. Introduction. This section describes acceptance procedures for the commissioning process.

b. Pre-requisites to Functional Performance Tests

(1) Prior to functional performance testing of each system, the commissioning team should observe and verify that the physical installation of components and systems being tested is substantially completed and in accordance with the contract documents.

(2) This should include component testing, start-up or activation of equipment and systems, completion of testing, adjusting and balancing and calibration and test of automatic controls.

c. General

(1) The functional performance test checklists contained in the approved commissioning plan should be used to document the results of the functional performance testing process.

(2) The functional performance testing process should be accomplished for all equipment, subsystems, systems and system interfaces. There may be several similar pieces of equipment, systems, etc., on a project. All must be tested for acceptance and there should be a separate checklist for each to ensure documentation specific to each is complete.

(3) Functional performance testing should progress from equipment or components through subsystems to complete systems. Functional performance testing will have to consider sequences of testing, starting with components and progressing towards complete systems. As a result, the causes of any functional problems should be easier to locate and correct.

(4) The specific tests, and the most efficient order of testing, will vary widely depending on the type of system, the number of systems, the sequence of construction, the relationship between building systems and specific tenant work, the degree of interaction between systems, the complexity of the controls sequence, the impact of system failures on health or safety and other factors.

d. Equipment and Subsystem Functional Performance Tests. Operate the equipment and subsystems through all specified modes of control and sequences of operation. Include full and part load and emergency conditions, as required by the contract specifications and the commissioning plan.

e. Systems Functional Performance Test. Following the equipment and subsystem functional performance testing, the overall systems must receive functional performance testing. Each system must be operated through all modes of operation, safeties, interlocks, load conditions and disturbances, in accordance with the contract specifications and the commissioning plan.

f. Verification and Documentation

(1) As each individual check or test is accomplished, the commissioning team should observe the physical responses of the system and compare them to the specified requirements to verify the test results. The actual physical responses of system

components must be observed. Reliance on control signals or other indirect indicators is not adequate. The input and output signals for each control component also need to be observed to confirm they are correct for each physical condition.

(2) Verification of the testing, adjusting and balancing report should be an integral part of functional performance testing.

(3) The commissioning team should record the result of each individual check or test on the pre-approved test and report form included in the commissioning plan, indicating acceptability or non-acceptability of the results.

g. Deferred Functional Performance Tests

(1) If any check or test cannot be accomplished for seasonal reasons, lack of occupancy or for other reasons, this fact should be noted along with an indication of when the test will be scheduled.

(2) If any check or test cannot be accomplished due to building structure or other building system deficiencies outside the scope of the systems work, these deficiencies should be resolved and corrected by the appropriate parties before completion of the commissioning process.

(3) Every check or test for which acceptable performance was not achieved should be repeated after the necessary corrective measures have been completed. This retesting process shall be repeated until acceptable performance is achieved.

h. Corrective Measures. If acceptable performance cannot be achieved, then the necessary corrective measures should be carried out. Normally, the ACO will identify the construction and/or design deficiencies causing problems and pursue a course of corrective action. The designer may be used to assist in diagnosing the cause of problems and should always provide recommended solutions to design deficiencies. The solutions to significant problems should be approved by the commissioning team, including the user. If the user cannot respond in a timely manner, decisions must be made without user input. Needless contract delays shall not be tolerated. The ACO must issue appropriate directions for corrective measures, through proper contractual channels.

i. Intersystem Functional Performance Tests

(1) When the functional performance of all individual systems has been proved, the interface or coordinated interaction responses between systems should be checked.

(2) The approach to intersystem performance testing should follow that previously described for systems.

j. Acceptance Documentation. A copy of the commissioning plan and functional performance test results should be added to the previously approved operations and maintenance manuals. Test reports should be submitted to the designer for review and approval.

k. Operator Training

(1) The system operator should be on site periodically during the construction phase, particularly during startup of equipment, testing, adjusting and balancing and during the entire functional performance testing process.

(2) Operator training should provide a complete overview of all equipment, components and systems with an emphasis on the following items:

(a) Documentation in the final operations and maintenance manuals.

(b) How to use the operations and maintenance manuals.

(c) System operational procedures for all modes of operation.

(d) Acceptable tolerances for system adjustments in all operating modes.

(e) Procedures for dealing with abnormal conditions and emergency situations for which there is a specified system response.

l. Final Acceptance. When requirements of the commissioning plan have been completed and satisfactorily documented and required documentation has been completed, submitted to the designer and accepted, the commissioning team should recommend final acceptance of the building systems.

10. POST-ACCEPTANCE PHASE

a. Introduction. Post acceptance commissioning is a critical step in ensuring the effective, continuous functioning of a facility*s systems. This phase of commissioning is normally outside the scope of the construction contract and must therefore be performed by the facility*s maintenance organization. The commissioning team must assure that its user representation is informed of the following post-acceptance commissioning measures recommended to maintain the proven performance of the facility.

b. Space use and occupancy will change over time. As use and function of facilities change, some systems need to be adapted to the changing requirements of occupancy and utilization. Also, as systems age, their performance may deteriorate. It is appropriate to maintain a history of the facility, recording changes and establishing the effect on the previously commissioned system. Throughout the useful life of systems, there will be a need for periodic recommissioning.

c. Post-Acceptance Commissioning Documentation.

(1) "As-built" documents must be revised to reflect modifications made to any part of the facility or systems.

(2) Any change in usage, installed equipment, loads or occupancy must be carefully monitored and documented. Evaluate the impact of the changes on the original commissioning plan and document these impacts.

d. Facility Alterations

(1) Notify the facility operator of alterations planned.

(2) Evaluate impact of planned alterations to building systems.

(3) Update "as-built" documentation including commissioning reports, to reflect alterations.

e. Maintenance Program

(1) Regularly maintain and service systems and equipment. Follow maintenance manuals and keep accurate records of work done.

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(2) Retest system periodically to measure the actual performance. System functional performance test checklists used in the acceptance phase should be a guide for retesting.

(3) Develop and maintain a standard method of recording complaints received regarding systems and operation.

(4) Discrepancies between predicted performance and actual performance and/or an analysis of the complaints received may indicate a requirement to recommission the system or review the commissioning plan.

APPENDIX B

**OUTLINE FOR THE PREPARATION OF
SYSTEMS COMMISSIONING SPECIFICATION**

OUTLINE SPECIFICATION

31 July 1995

SYSTEMS COMMISSIONING

NOTE: Only systems commissioning activities which occur during project construction will be defined in the contract specifications. This specification section may be inserted into the General Provisions of the Contract Specifications, or the Technical Provisions as determined by the design engineer. Other specification sections having activities affecting systems commissioning will make reference to this section, and will direct that those activities be coordinated to permit overall systems commissioning as specified herein. Each project will require adaption of this specification to meet requirements of design intent, project location, construction methods, and construction team organization and management structure.

PART 1 GENERAL REQUIREMENTS

1.1 DESCRIPTION OF WORK

1.1.1 The "System" as referred to in this section of the specifications shall include, but not be limited to, the following subsystems and components of subsystems: _____
_____.

1.1.2 The Contractor shall verify operational and functional performance of the System for compliance with the "Design Intent" as described (in the following Section(s) of the Contract Specifications: _____
_____.)

[and] [below for the following subsystems: _____.]

NOTE: The design engineer will include in the specifications a complete description of system operation and performance data for informational purposes only. "Design Intent" information specified herein shall include: (a) the general philosophy and goals of the total system, (b) an explanation of selected components of the overall system and the expected interaction between components and subsystems, (c) data on performance requirements of the total system, (d) performance requirements of designated zones, and (e) an overview of control systems and their integration with other systems.

1.1.3 The Contractor shall document all tests and inspections performed on the System as part of the commissioning process.

1.1.4 The Contractor shall verify the existence and application of operation and maintenance (O&M) manuals, as-built or record drawings and documents, spare parts lists, special tools lists, and other items as may be specified herein for support of the System. Contractor shall make any and all necessary corrections to O&M manuals and procedures if errors are discovered during the commissioning process.

1.1.5 The Contractor shall coordinate and direct training of personnel for the operation and maintenance of the System in accordance with detailed requirements found in the technical and execution sections of this specification.

1.1.6 The "Systems Commissioning Team" as referred to in this section of the specifications shall be composed of the team members listed below. The Contractor shall be added to the Team after contract award, and shall designate members from the Contractor Group to participate in the precommissioning activation inspection and the functional performance testing specified herein. In addition, the Government will be represented by an official of the Contracting officer, the Designer or Design Agent Representative, and the Using Agency. All commissioning inspections and testing will be accomplished in the presence of a representative of the Contracting officer.

NOTE: Where possible, the Designer, or a Design Agent Representative, shall be included as a member of the Commissioning Team. The planning and programming of either Title II services or in-house support will be required for the participation of the Design Agent Representative. For certain highly complex systems, it may be appropriate to include a manufacturer*s representative as a member of Contractor Group on the Commissioning Team. Designer shall consider the degree to which such participation is required to assure fulfillment of the full contract requirements. Due to the added costs, this option should be only utilized where absolutely necessary to assure provision of a fully functioning system in accordance with design intent.

NOTE: Provision of a fully commissioned system is the responsibility of the Contractor. Therefore, Contractor Group members of the Systems Commissioning Team, through participation in the planning, management and oversight of all construction activities related to equipment approvals, performance testing and commissioning of the systems identified herein, must be able to assure the Government that all systems have been properly tested and commissioned. The Government, User, construction and design elements are intended to participate fully as an adjunct to the Contractor Group Team members. It is intended that through this participation, the Contractor Group Team members will be provided timely access to all design information necessary to resolve questions as to intended performance of the systems specified. In addition, the Government will be sufficiently involved in the development of commissioning and performance testing programs to assure timely review of plans and procedures submitted by the Contractor. The purpose of this will be to provide fully functional systems which interact to meet all contract performance requirements. The participation of the Government Commissioning Team members shall not relieve contractor of any responsibility for compliance with the requirements of the contract.

The team shall include the following members:

a. Contractor--The Contractor Group representatives shall include but not be limited to the following individuals:

Chief Quality Control Representative
Mechanical Representative
Electrical Representative
Testing, Adjusting, and Balancing Representative
Instrumentation and Controls Representative

b. Contracting Officer Representative

c. Using Agency Representative (Optional)

d. Designer or Design Agent Representative (Optional)

NOTE: The design engineer will list special requirements (if any) for qualification of the Commissioning Team, such as previous work experience, licensing, registration, membership in societies, etc. See Appendix A for guidance in selecting special requirements.

1.2 THE COMMISSIONING PROCESS

1.2.1 The Contractor shall review and verify the commissioning schedule and requirements for the interface between all building and construction trades in order to prevent delays in the commissioning process. Contractor's verification shall be indicated by his signed approval.

NOTE: The extent to which each commissioning activity is required on a particular project shall be clearly defined in the Commissioning Plan.

1.2.2 Commissioning Plan. The commissioning plan shall be prepared by the Contractor. It shall describe how the commissioning process will be organized, scheduled, and documented. The plan shall include:

- a. The composition of each Subcontractor*s group representation to the Commissioning Team.
- b. A list of activities required to commission the system and its subsystems.
- c. A schedule for each activity linked to the master project schedule to make possible the coordination necessary between trades and trade divisions.

1.2.3 Precommissioning Meeting. _____ [days] [months] prior to start of the scheduled systems activation inspection, the Contractor shall hold a precommissioning meeting with all Team members in attendance. The purpose of the meeting is to prepare for the systems activation inspection, and to ensure that all Team members are ready to begin full-scale commissioning. In the event that the Contractor is unable to hold the precommissioning meeting, or conduct the systems activation inspection, at the scheduled times as shown in the Commissioning Plan, the following remedies will apply: _____

Note: Designer must ensure that the time provided between the precommissioning meeting and the systems activation inspection is adequate to allow each Commissioning Team member to assemble representatives of their group and prepare for full-scale commissioning. For a complex project this may require more than 30 days. Therefore, a minimum of 30 days will be specified. Sufficient notification time will be also allowed for the precommissioning meeting.

1.2.4 Systems Activation. After the physical installation of all systems and subsystems has been completed, the Contractor shall insure that all building services, such as electrical power, central steam supply, natural gas, water, sewer, etc., have been connected and started. The System shall be activated after the following building services have been connected and started: _____

The Commissioning Team shall perform a system activation inspection to ensure that the system is operational and ready for testing and balancing. All subsystems shall have been inspected, started by trained personnel, and tested by the Contractor to ensure that they function as required, and that all subsystems are operational at the time commissioning activities begin.

1.2.5 Testing, Balancing and Adjusting. Testing, balancing and adjusting of the System shall be accomplished by [the Contractor) [_____] in accordance with Section[s] _____ of the contract

specifications. The Testing, Balancing and Adjusting Report shall be submitted to the Contracting Officer, and members of the Commissioning Team who have not received the information.

NOTE: Testing, balancing and adjusting of the System shall be performed by a single organization approved by the Contractor as having the knowledge and experience to carry out the work. The scope of testing, balancing and adjusting shall be clearly defined in the contract specifications and on the drawings, and shall include Ca) details of all systems to be tested and balanced, (b) specific performance requirements, and (c) required documentation.

Procedures for testing, balancing and adjusting shall be performed in accordance with the standards set forth in Sections _____ of the specifications.

NOTE: Designer shall include standards such as (a) "HVAC: Testing, Adjusting & Balancing" published by the Sheet Metal and Air Conditioning Contractors National Association, Inc., (b) "National Standards" published by the Associated Air Balance Council, (c) "ASHRAE Standards" published by the American Society of Heating, Refrigeration and Air Conditioning Engineers, (d) "National Fire Protection Standards" published by the National Fire Protection Association, and (e) "Operation of Munciple Wastewater Treatment Plants--MOP 11" published by the Water Environment Federation.

1.2.6 System Performance Verification, System performance verification shall be accomplished in accordance with the System and Subsystem performance check lists which are included herein. The verification procedure shall include:

- a. Testing and verification that all systems and subsystems perform to the standards in Sections _____. A report indicating that testing has been performed and has verified the system to be in conformance with the contract shall be made available to the Commissioning Team.
- b. Completion of the verified check lists signed by the Contractor, and the required Commissioning Team members..
- c. Joint investigation and correction of problem conditions where a system, sub-system, or equipment component does not achieve specified performance standards.
- d. Recording seasonal and occupancy conditions in effect at time of the verification described heretobefore.

1.2.7 Demonstration and Instruction. A systems demonstration and operating instructional (D&I) program shall be organized and developed by the Contractor, and presented to the Using Agency operating and maintenance staff. The Program shall include, but not be limited to, the following:

- a. Detailed schedule of instruction periods for specific sections of the installation.
- b. Introduction to the operating and maintenance manuals.

The Contractor shall assign each element of instruction to specialist members of the Commissioning Team who were involved in the installation and are familiar with the details of the System being commissioned. The time required to provide the demonstration of the System and full instruction on operating and maintenance of the installation shall be as follows: _____.

NOTE: The D&I program will be scheduled over a period of time that will be commensurate with the size and complexity of the project.

1.3 CONDITIONS OF WORK

The Contractor shall furnish all labor, equipment and materials to accomplish complete systems commissioning as specified in this section of the specifications.

NOTE: Design engineer will describe any special requirements for commissioning due to unique work conditions, labor requirements, availability of equipment and materials, project location, etc. See Appendix A for guidance on selecting special requirements for work conditions. In some cases, for example where a long commissioning period is required for a wastewater treatment plant, it may be feasible to utilize existing installation manpower under contractor/A-E supervision.

1.4 WORK SCHEDULE

NOTE: Design engineer will develop a schedule or "Work Plan" for commissioning to include start-up, testing, and adjustment of all components of the System. See Appendix A for guidance on developing a commissioning schedule.

1.5 COMMISSIONING START-UP AND COMPLETION

The Contractor shall complete interim systems commissioning during the initial start-up and operations phase, and shall complete follow-up and final systems commissioning during the final construction inspection and acceptance phase.

NOTE: Designer will estimate the approximate dates of commissioning and describe any special requirements for the commissioning process such as special loading conditions and seasonal variations in weather or climatic conditions. These dates may change as the date of contract award approaches. Note that on larger projects, commissioning will begin only after beneficial occupancy of the project.

1.6 REFERENCES

NOTE: Designer will list applicable publications with dates to be used in systems commissioning and which will be referenced within this specification section. An example is "ASHRAE Guideline 1-1989, Guidelines for Commissioning of HVAC Systems" published by the American Society of Heating, Refrigeration and Air Conditioning Engineers.

1.7 DOCUMENTATION

The Construction Contractor shall provide to each member of the Systems Commissioning Team six (6) copies of the following items as soon as they become available:

1.7.1 Certified and approved start-up and testing reports for all subsystem equipment that comprise the System. Commissioning documentation shall include control schematics of the total system and all subsystems.

1.7.2 Records of required inspections for code compliance, and documentaion of approved permits and licenses to operate components of the System.

1.7.3 Operating data which shall include all necessary instructions to the Owner*s operating staff in order to operate the system to specified performance standards.

1.7.4 Maintenance data which shall include all necessary information required to maintain all equipment in continuous operation, such as the testing, balancing and adjusting report and the as-built drawings.

NOTE: The required documentation for a particular project will be detailed in this section of the specifications.

1.8 SUBMITTALS

The Contractor shall submit to the Contracting Officer for approval the following items prior to starting the commissioning process:

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

1.8.1 Contractor Commissioning Representatives. A list of Contractor representatives on the Commissioning Team and their qualifications shall be submitted at least _____ [weeks] (months) prior to the start of pre-commissioning checks. Any proposed revision to this list must be submitted prior to the start of the impacted work.

1.8.2 Commissioning Plan

NOTE: Designer will identify all components of the plan for conducting and completing systems commissioning. See Appendix A for guidance in developing the systems commissioning plan.

1.8.3 Training Plan

NOTE: Designer will identify all elements of the plan to train personnel from the Using Agency in the operation and maintenance of the System. See A for guidance in developing the training plan.

1.8.4 Testing Equipment

NOTE: Designer will identify and specify all testing equipment, apparatus, related tools, etc., the systems to be tested with such equipment, the reason the equipment is required, the source for obtaining the equipment, and the price and delivery date of each component or element. The contractor will be required to provide all such items.

1.8.5 Test Procedures. Detailed procedures for precommissioning checks and functional performance tests shall be submitted at least _____ [weeks] (months) prior to the start of precommissioning checks.

1.8.6 Test Schedules. Schedule for precommissioning checks and functional performance tests shall be submitted at least _____ [weeks] [months] prior to the start of precommissioning checks.

1.8.7 Test Reports. Completed precommissioning checklists and functional performance test checklists shall be organized by system and by subsystem and submitted together. The results of failed tests shall be included along with a description of the corrective action taken.

1.9 CONTRACTOR RESPONSIBILITIES

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1.9.1 The Contractor shall deliver a commissioned installation to the Government that meets all performance requirements in accordance with the contract documents.

1.9.2 The Contractor shall provide all necessary access facilities to those working on the installation of all systems so that the Commissioning requirements can be fulfilled completely.

1.9.3 The Contractor shall consult with subcontractors to ensure that sufficient time is allowed and fully identified on the Master Schedule for the proper commissioning of all systems.

1.9.4 The Contractor shall plan, organize and implement the commissioning process as identified in the Contract Specifications.

1.9.5 The Contractor shall arrange consultation with the Contracting Officer to provide clarification of the design described in the specifications, if the subcontractor deems such a meeting necessary.

1.9.6 The Contractor shall assign a Commissioning Team, comprised of qualified sub-trade specialists who are coordinated by a competent, experienced supervisory person.

1.9.7 The Contractor shall supply complete instruction and information relating to the operation and maintenance of all equipment and systems.

1.9.8 The Contractor shall deliver a system that performs within the ability of the equipment and design specified in the contract.

NOTE: Design engineer will list applicable specification sections that identify other responsibilities, including various trades involved in the work, during the systems commissioning process. The Owner or Using Agency will (a) provide an operations and maintenance staff that possesses sufficient skills, education and aptitude to be able to operate and maintain the installation following an appropriate period of instruction, (b) assign selected staff to observe the installation and commissioning prior to final demonstration and turnover, in order to become fully familiar with the installation and the design intent of the system, Cc) ensure that the Design Authority*s contract includes such services that are defined herein as the Design Authority*s responsibility, (d) arrange the schedule of occupancy such that the commissioning process can be carried out without undue interference. The Design Agent or Authority will (a) ensure that the commissioning process is fully identified and specified in contract documents, (b) include in the contract documents a complete description of the systems operation and performance and requirements for commissioning the system, Cc) specify equipment and appurtenances to meet the design criteria, (d) verify and certify the performance of systems on completion of the testing, balancing and adjusting process, (e) specify in contract documents check lists for performance testing and verification, (f) assign a qualified person to work with the Contractor and Owner on the entire commissioning process, and Cg) issue a definitive deficiency list at the time of system activation and on completion of the systems performance verification procedure.

PART 2 PRODUCTS

2.1 TESTING AND INSTRUMENTATION

2.1.1 The Contractor shall provide the following testing and instrumentation equipment to be used in the commissioning process: _____
_____.

NOTE: Designer will list applicable equipment to be used for testing and instrumentation during the systems commissioning process, with special emphasis placed on load simulation.

2.1.2 The Contractor shall provide all utilities necessary to carry out testing and instrumentation as part of commissioning process, including such expendible items as water, fuels, chemicals and other materials. The Contractor shall also provide any equipment or device required for access such as platforms, scaffolds, ladders.

PART 3 EXECUTION

3.1 GENERAL

The Contractor shall coordinate with the Commissioning Team in the construction phase of the project to assure compliance with all systems commissioning requirements.

3.2 PROCEDURES

3.2.1 The Contractor shall schedule a pre-construction conference meeting to establish requirements for systems commissioning throughout the construction phase.

3.2.2 The Contractor shall submit to the Contracting Officer 30 days after contract award the complete commissioning plan which shall include:

3.2.2.1 Responsibilities of each trade affected by the commissioning process.

3.2.2.2 Requirements for documentation as listed [in this Section] [and] [in Section(s) _____] of the Contract Specifications.

3.2.2.3 Requirements for documentation of commissioning tests and inspections required by code authorities and governing agencies.

3.2.2.4 Requirements for the commissioning program during specific operational seasons with partial and full loads as specified [in this Section] [and] [in Section(s) _____] of the Contract Specifications.

3.2.2.5 Requirements and format for a training program for operations and maintenance personnel.

3.3 INSPECTION AND TESTING

The Contractor shall designate Commissioning Team members to participate in the pre-commissioning inspection and the functional performance testing specified herein. In addition, the Government shall be represented by an official of the Contracting officer. Each checklist item shall be completed by the Commissioning Team. Acceptance by each Commissioning Team member of each pre-commissioning checklist item shall be indicated by signature and date unless participation by that individual is not required. Acceptance by each Commissioning Team member of each functional performance test checklist shall be indicated by signature and date.

3.3.1 TESTS

The pre-commissioning checks, inspections, startup and performance testing shall be accomplished in detail as specified in other parts of these specifications, or as recommended by the manufacturer, or as required by a referenced code or standard.

NOTE: Where checking, testing, and inspection methods are not specified in other Sections, methods shall be established and provided in this Section which will provide the information required. Testing and verification requirements in related Sections are independent of the requirements of this Section, and shall not be used to satisfy any of the requirements specified in this Section.

All testing and verification required in this Section shall be performed during the Commissioning phase. The Contractor shall provide all materials, services, and labor required to perform the pre-commissioning checks and functional performance tests.

3.3.1.1 Pre-Commissioning Checks

Pre-commissioning checks shall be performed for the items indicated on the checklists in Section(s) _____. Any deficiencies discovered during these checks shall be corrected and retested in accordance with the applicable contract requirements.

3.3.1.2 Functional Performance Tests

Functional performance tests shall be performed for the items indicated on the checklists in Section(s) _____. Functional performance tests shall begin only after all pre-commissioning checks have been successfully completed. Tests shall prove that all modes and sequences of operation are correct, and shall verify all other relevant contract requirements. By verify it is meant that contract requirements are satisfied by testing results. Testing shall begin with equipment or components and shall progress through subsystems to complete systems. Upon failure of a functional performance test checklist item, the Contractor shall correct all deficiencies in accordance with the applicable contract requirements. Testing of the checklist shall then be repeated until it has been completed without errors.

END OF SPECIFICATION