

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.

(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.

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(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.