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1.0 PURPOSE, SCOPE, AND GRADED APPROACH

A. Purpose

To establish the minimum requirements and guidance for a systematic approach to commissioning (Cx) for LANL projects within the scope defined below.¹

B. Scope

1. This chapter applies to all projects directed by the LANL Construction Management Division² and all major modifications³ including all International Existing Building Code Level 3 alterations⁴, new buildings and additions, transportables, and other projects identified by the Design Authority Representative.
2. *Guidance: Projects not subject to this chapter in Hazard Category 2 or 3 (nuclear) or High/Moderate Hazard non-nuclear facilities must, however, perform post-modification testing; see [AP-341-801](#), Post-Modification / Post-Maintenance Testing.*
3. This chapter presents the top-level Cx process to be followed. The development and use of numerous detailed sub-processes within and below these top-level processes is required to implement this process.
 - a. When the Cx is performed entirely by LANL, Construction Management Procedures CMP 400 and CMP 401 shall be used.
 - b. If the Commissioning Agent (CA) is a subcontractor, then they may model their test procedures after the LANL procedures or must submit their own system and component test program procedures to the Commissioning Authority (LCA) and LPM for approval.
4. Projects⁵ subject to this chapter shall be evaluated, in the preliminary design phase, for the specific applicability of this chapter by the LCA and the LANL Project Manager (LPM).
5. When this chapter is applicable, the graded approach to be applied, and the responsibilities of the various project entities within the Cx process must be

¹ This chapter provides a necessary and sufficient Cx process for LANL; however, LANL has other programs that provide inspections that are pre-requisites to the Cx process (e.g., the ESM Ch 16 IBC Program that ensures the owner reviews design and inspects work for code compliance)

² See [SD350](#), Management of Projects

³ Per ESM Ch 1 Section Z10, change to a nuclear facility that substantially changes the existing safety basis for the facility

⁴ See ESM Ch 16 Section IBC-GEN App B, LEBC

⁵ For the purposes of this chapter, a project is defined as all activities associated with the design, installation, construction, retro-fit, or change in the intent or functionality of structures, systems, or components.

determined in concert with the LCA. The LPM must ensure construction contracts include the necessity to cooperate and coordinate with Cx activities.

6. Exclusions from this process are addressed under that heading below.
7. Attachment A provides a process flowchart of the major activities within the Cx process and the key entities responsible for those activities. The roles identified are defined in under the Responsibilities and Duties heading, and the specific individual or entity fulfilling that role on a project may vary depending on the contractual responsibilities. For example, the CA may be a LANL Startup Specialist or a subcontractor's testing manager.
8. General definitions and requirements for variance processing are contained in ESM Chapter 1 General, Section Z10.
9. When the project is subject to this chapter, the following Cx and testing activities shall follow the requirements of this chapter except as specifically excluded (see that heading below).
 - a. Facility
 - i. Cx and testing on newly constructed facilities and engineered modifications.
 - b. Process System
 - i. Mechanical and Electrical Component Testing

Mechanical and electrical component testing shall be included as a segment of the overall system or facility testing.
 - ii. Control System Functionality

Functional testing of individual control loops and instrumentation within that loop including communication with central control systems or digital control systems.
 - iii. Overall System Performance to Design

Integrated functional testing and tuning of all control loops and individual components which comprise a process system to demonstrate the systems overall performance to design.
 - c. Post-Modification Testing

Testing of systems and components with engineered modifications and that require a new demonstration of performance to design basis.

d. Programmatic Testing

Testing of new or modified components or systems of experimental equipment or prototypes which require a demonstration of performance to design basis.

C. Graded Approach

1. A graded approach is used to determine the appropriate level of Cx rigor to achieve a safe, efficient, and reliable product without performing unnecessary testing, witnessing, and documentation.
2. The graded approach effort shall consider the Management Levels (ML-1, 2, 3, or 4) applied by the project team, the complexity of the components and systems to be tested, and the risks their failure or inadequate performance would present to the project.
3. The LCA shall determine, for each project, the appropriate level of rigor and documentation to be applied during the Cx phase. Where necessary the LCA shall utilize system or specialty SMEs to assist in this determination. The final graded approach for Cx must be reviewed, approved and documented by the LPM and LCA.
4. For each project the overall graded approach and the ML levels will have been addressed and documented as they apply to the other functions and phases of the project (e.g., engineering, procurement, and construction). Although the CA may have been involved in that determination, the rigor and documentation applied during Cx must be addressed separately and specifically (see Table 1 below for minimum requirements). The graded approach shall determine the:
 - specific testing requirements,
 - level of verification signatures,
 - need for witness and hold points,
 - need for a Test Review Board (TRB), and
 - documentation requirements.
5. Refer to CMP 400 (*rev 0 Section 2.0*) for further guidance on the Cx graded approach, and to LANL P330-1 for the overall QA process.

Table 1 – Minimum Level of Rigor in Cx

Level of Rigor	Management Level			References
	ML-1/2	ML-3	ML-4	
PROGRAM-LEVEL REQUIREMENTS				
Commissioning Plan	R	R	O	CMP 400
System Acceptance Test Procedures	R	R	O	CMP 400
Test Review Board	R	O	-	CMP 400
Test Summary Report	R	R	O	CMP 400
Test Technician Qualification Program	R ⁶	R	R	CMP 400
COMPONENT-LEVEL REQUIREMENTS				
Component-level test with results recorded on data sheets	R	R	R	CMP 401
Electrical acceptance test and record on data sheets	R	R	R	ESM Ch 7 D5000 Master Spec 26 0813
Electrical control scheme verification and recorded on data sheets	R	R	R	CMP 400
HVAC test, adjust, and balance (TAB)	R	R	R	ESM Ch 6 D30HVAC Master Spec 23 0593
Instrument control loop verification and recorded on datasheets	R	R	R	CMP 400
Rotating equipment mechanical baseline operating data (vibration, rotation, bearing temperatures) and record on data sheets	R	R	R	CMP 401
Rotating equipment electrical baseline data (starting & running current, voltages, bearing temperatures) and record on data sheets	R	R	R	CMP 401
Piping system cleanliness verification and recorded in a test procedure	R	O	O	CMP-401
Process instrument calibration and recorded on data sheets	R	R	O	CMP 401
Turnover and acceptance of SSCs	R	R	R	AP-350-420 Project Turnover and Acceptance
Vendor equipment factory acceptance test (FAT) and record on data sheets	O	O	O	CMP 401
Vendor equipment field test and record on data sheets	R	R	R	CMP 401

R = Required O = Optional and when appropriate

⁶ Note: Project (job) specifications may require a subcontractor to comply with NQA-1 requirements.

D. Exclusions⁷

1. Security⁸
2. Fire protection and fire alarms⁹
3. Fume hoods and HEPA filters¹⁰
4. Telecommunications¹¹
5. Weapons components¹²
6. Electrical acceptance testing on >600 volt systems¹³
7. Post-maintenance testing (and post-mod testing not meeting scope statement on page 1)¹⁴

2.0 REFERENCES**A. LANL**

1. CMP [400](#) Startup and Commissioning Process Procedure
2. CMP [401](#), Process Component Test Procedure
3. P330-1 – Graded Approach for the Application of Quality Assurance Requirements
4. SD 330 – LANL Quality Assurance Program
5. SD 350, Management of Projects
6. Other chapters of the Engineer Standards Manual and related specification sections
7. [AP-350-420](#) – Project Management Procedure, Turnover and Acceptance

⁷ These systems have well-established Cx programs defined elsewhere at LANL; better integration of some of these programs with this chapter may be a future enhancement.

⁸ Security system Cx performed by LANL S&S groups (e.g., [PS-2](#)); see ESM Chapter 9 Security and related LANL Master Spec Div 28 sections [here](#)

⁹ Controlled by LANL Div 21 and 28 Master Specifications [here](#)

¹⁰ Performed by LANL IH per [P101-16](#), Local Exhaust Ventilation and HEPA Filtration Systems; related Div 23 and 43 LANL Master Specs

¹¹ Performed by LANL Network and Infrastructure Engineering ([NIE](#)) Division; related LANL telecom Div 27 Master Specifications [here](#)

¹² Weapons system components including WR and prototypes are excluded; systems and equipment for the R&D (e.g., design and testing) of such components are not excluded if project is under CM Division management

¹³ See ESM Chapter 7 Electrical Section D5000.

¹⁴ Applicable and appropriate testing performed following maintenance to verify that a particular SSC, piece of equipment, or process system performs its intended function based on its design criteria and that the original deficiency has been corrected and no new deficiencies were created (DOE O 433.1). Post-Maintenance Testing performance is the responsibility of the maintenance organization conducting the maintenance as outlined by the system engineer, and should not be confused with Post-Modification Testing. Small modifications (e.g., engineered equivalent replacements and some IEBC Level 1 and 2 mods) not meeting this Chapter's applicability statement follow LANL [AP-341-801 Post Modification/Post Maintenance Testing](#) rather than this chapter when in Cat 2/3 nuclear and High/Moderate Hazard facilities.

B. Department of Energy

1. DOE O 425.1C – Order on Startup and Restart of Nuclear Facilities
2. DOE O 414.1C – Order on Quality Assurance
3. 10 CFR 830.122 – Quality Assurance Criteria (nuclear facilities)

C. National Standards

1. ASME NQA-1-2000 or later, Quality Assurance Requirements for Nuclear Facility Applications

3.0 ACRONYMS AND DEFINITIONS

Beneficial Occupancy ¹⁵	The limited acceptance of a facility by an owner/user from the LANL Project Manager to allow utilization of the assets prior to final acceptance of the facility (aka Substantial Completion)
Component Testing (Pre-functional testing)	The individual pieces of equipment are confirmed to be capable of performing in accordance with the specifications, drawings and manufacturer’s requirements. This is documented in a component test data sheet provided by and completed by the Commissioning Agent. The information recorded on the data sheet provides baseline data for future re-evaluation of the components or systems.
Cx	commissioning
Commissioning Agent (CA)	A qualified and experienced Cx process person, company, or agency assigned to a specific project, working under the guidance of the LANL Commissioning Authority and the LANL Project Manager. The CA leads, plans, coordinates and implements the overall project-specific Cx process activities. Qualification is per the judgment of the LCA, but shall be at least a Level II. Must be independent of all non-LANL construction subcontractors.
Commissioning Final Report	The documentation package that records the Cx plan, test procedures and results of the commissioning process, including the recorded performance of the various systems and components. The final report is issued to the facility owner for final acceptance of the facility
Commissioning Plan (Cx Plan)	The plan which defines the Cx process, including schedules, responsibilities, document requirements and Cx test requirements which are developed in increasing detail as the project progresses through its various phases.
Commissioning Process	The quality-focused process for enhancing the project delivery process. The process focuses upon verifying and documenting the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet project requirements.
Commissioning Specification	The specific detailed requirements that defines the subcontractor’s objectives, responsibilities, scope, implementation, documentation and acceptance phases for the Cx process. This is developed in the design phase for inclusion in the construction documents.

¹⁵ Ref. ESM Chapter 16 – IBC Program (*Section IBC-GEN Article 5.14*) Certificate of Beneficial Occupancy/Certificate of Occupancy.

Commissioning Team	The team that coordinates, monitors, and documents compliance with the owner’s project requirements and is responsible for working together in carrying out the Cx process.
Commissioning Test	Tests by which specific documents, components, equipment, assemblies, systems, and system interfaces are confirmed to comply with the criteria described in the Owner’s Project Requirements. Including all modes and sequences of control operation, interlocks, conditional control responses and all specified responses in accordance with design basis requirements.
Commissioning Test Procedure	Written, detailed, step-by-step protocol that defines the means and methods, personnel, and expectations for conducting tests on components, equipment, assemblies, systems, and system interfaces. The procedure has provisions for verifying all relevant data, recording the results, and identifying the requirements and responsibility for each test.
Final Acceptance	Final acceptance is the written acceptance issued to the subcontractor by the Project Manager after the subcontractor has achieved final completion
Functional Testing	Testing of a component or subsystem against prescribed acceptance criteria, based on the owner’s project requirements, vendor documentation, or industry standards to ensure that the SSC’s functions and follows a prescribed sequence of operations according to the predetermined design requirements.
Final Completion	Final completion occurs when the work is fully and finally completed in accordance with the construction subcontract documents and all deficiencies have been corrected
Graded approach	A process to determine the level or rigor to be used for a particular SSC based on the importance to the work, safety, health, environmental compliance, safeguards and security, programmatic importance, magnitude of potential hazard, and financial impact of the SSC.
Installation verification	The initial portion of the Cx process includes observations and punch-lists recorded and performed by the field engineer to confirm that all equipment is installed in accordance with the specifications and drawings.
LANL Commissioning Authority (LCA)	An independent Cx process person designated by the LANL Construction Management Division Leader to manage the Cx at LANL and, for facilities, to represent the LANL Building Official’s interests in matters related to Cx. Shall meet Level III qualifications of Appendix A.
Level of rigor	The level of strictness, detail, validation and judgment to be applied to a specific task or evaluation.
O&M	Operations and Maintenance, the group responsible for the maintenance and operation of facilities and systems after final acceptance.
Performance Testing	Performance tests are conducted to verify performance of entire systems and multiple systems against a defined set of requirements and parameters. Examples of systems which typically require performance tests are HVAC systems, process systems, critical capacity mechanical equipment and integrated operation of systems.
Post-Modification Testing	Validates that the system or component performs as intended and operates within the design requirements after the change is installed and before turnover to operations (DOE-STD-1073).
SME	Subject matter expert
Structure System and Components (SSC)	Structure - an element or a collection of elements to provide support or enclosure such as a building, free standing tank, basin, dikes, or stacks. System - a collection of components assembled to perform a function such as piping, cable trays, conduits, or HVAC. Component - an item of equipment such as a pump, valve, or relay, or an element of a larger array such as a length of pipe, elbow, or reducer

Substantial Completion	Substantial completion is a legally recognized point in time that allows the owner to take occupancy of the facility even though there is work yet to be completed and documentary, regulatory, and contractual closeout requirements yet to be met. (aka Beneficial Occupancy)
Test Review Board (TRB) ¹⁶	The group of representatives from the Design Authority, Quality Assurance, LANL Engineering, LANL Startup and Testing Services Group, and Facility Operations responsible for reviewing and approving Cx test results.
Testing Contractor	The person, company, or agent responsible to the prime subcontractor for: <ul style="list-style-type: none"> • Making inspections required for Cx • Coordinating, scheduling, and managing Cx activities of the Subcontractor, sub-tier subcontractors, and suppliers • Obtaining documentation required for Cx from the Subcontractor, sub-tier subcontractors, and vendors

4.0 RESPONSIBILITIES AND DUTIES

There are many individual roles in the overall execution of a project from inception to occupancy and operations; however, this chapter addresses only Cx and the responsibilities and duties of those individuals or positions which have an active role in the Cx process or a direct interface.

A. LANL Project Manager (LPM)

1. Approves the scope of Cx services required and arranges for such services (in-house and/or subcontract).
2. Ensures funding is available to support programs and personnel necessary to accomplish the Cx testing scope of work.
3. Ensures funding and resources are available for the Test Review Board (TRB) representatives and facilitates their efforts in reviewing and approving project Cx test results.
4. Reviews and approves the Cx plans and procedures.
5. Reviews and approves the Final Test Summary Report.
6. Ensures construction subcontracts direct the cooperation of the constructor (e.g., through exhibits or specification sections)

B. Responsible Subject Matter Expert (SME)

1. Participate as a member of the Cx team and provides technical input as required.
2. Support and witness field Cx tests as necessary.
3. Review and approve Cx plans and other documents as submitted by the CA.

¹⁶ CMP-400 *Startup and Commissioning Process* provides instruction on how to organize a Test Review Board

C. LANL Commissioning Authority (LCA, aka Startup Manager)

1. Point-of-contact (POC) and support for all Cx issues including providing clarification, making recommendations on variance requests, maintaining the chapter and master specifications, and chairing the Chapter 15 Technical Committee.
2. Review CA status reports.
3. Establish, review, and accept the CA's qualifications for a project assignment.
4. Review and approve the qualifications of subcontractor Cx team members.
5. Review and approve all Cx activities conducted by the Project CA.
6. Participate in project reviews as required.
7. Review and approve the Final Commissioning Report.

D. Commissioning Agent (CA) (LANL or Third Party)

1. Hold a Level II qualification as a minimum.
2. Establish the Cx Plan and coordinate the Cx Team.
3. Provide support to the owner to evaluate and verify that the owner's project requirements for the facility are satisfactorily achieved and documented during all phases of the project.
4. The CA's roles and responsibilities must be in agreement with the contractual requirements established for the project. The specific requirements may significantly change based on design and construction approach (e.g. design-bid-build, design-build, etc.) selected by the Project Manager.
5. The CA's responsibilities include the following tasks:
 - a. Develop the Cx process, plan, documentation and requirements through out the life of the project.
 - b. In conjunction with the LCA, establish a Project Commissioning Team and define roles and responsibilities.
 - c. Develop a formal Cx Plan, budget and schedule.
 - d. Coordinate the Cx activities in a safe, logical, sequential, and efficient manner utilizing standardized protocols defined in CMP 400¹⁷.
 - e. Define the Cx requirements and activities to the construction manager, subcontractors, architect/engineer of record, and the owner's project leader to

¹⁷ Reference CMP 400 (R0 Section 5.0 – Conduct of Testing)

- ensure that Cx activities are included in the master design and construction schedules.
- f. Plan and conduct Cx planning meetings.
 - g. Review design and construction documentation with respect to Cx requirements.
 - h. Review design and construction installation verification reports and Cx test data.
 - i. Identify, document and report Cx deficiencies. Coordinate re-testing as necessary, until satisfactory performance is achieved.
 - j. Maintain a master test deficiency and resolution log and separate testing record.
 - k. Provide to the owner/project manager written progress reports and test results with recommended actions.
 - l. Review non-conformance and corrective action documentation that has a Cx impact.
 - m. Review the Cx documentation utilized to establish Cx acceptance.
 - n. Support the review of O&M submittals from a life-cycle O&M perspective, as required.
 - o. Provide documentation as defined under the Documentation heading below.
 - p. Review and approve subcontractor installation verification checklists prior to the commencement of Cx activities.
 - q. Provide coordination with the project STR for vendor training of owner personnel¹⁸.
 - r. Observe components and systems installations. Attend planning and job-site meetings to obtain information on construction progress
 - s. Witness Cx tests when performed by subcontractors or independent agencies to assure that proper procedures are being followed and to validate acceptable results.
 - t. Conduct retests of systems or components which failed the initial testing requirements.
 - u. Develop System Integrated Test Procedures when required.
 - v. Work with the installing subcontractors and include data from vendor tests.
 - w. Analyze all test data collected to verify actual performance results for inclusion into the final Cx report and when required submit for TRB approval.

¹⁸ Reference AP-350-420 r0 Section 3.4 Systems & Structures Training

E. Test Technician (aka Test Tech or Startup Test Specialist)

1. Conduct tests as assigned by the CA in accordance with approved test procedures and in support of the Cx Plan and Schedule.

5.0 APPLICABLE CODES AND STANDARDS

- A. ASHRAE – American Society of Heating, Refrigeration, and Air Conditioning Engineers
- B. USGBC and LEED – US Green Building Council’s Leadership in Energy and Environmental Design
- C. NECA – National Electrical Contractors Association
- D. NETA – International Electrical Testing Association, Inc.
- E. ASME – American Society of Mechanical Engineers
 1. ASME NQA-1-2000 or later – Quality Assurance Requirements for Nuclear Facility Application (Non-Mandatory Appendix 2A-1 – Guidance on the Qualifications of Inspection and Test Personnel)

6.0 CX PROCESS REQUIREMENTS AND PHASES**A. Requirements**

1. Conduct of Tests¹⁹

The CA, and or the Test Techs shall test all structures, systems, and components within the scope of the project in accordance with the rigor of testing determined during the Graded Approach review and any specific or special tests as called out in the project contract documents. The conduct of test procedures shall ensure the safety of personnel and plant equipment. Notification tags and lock outs, as appropriate, shall be verified prior to performance of each test procedure or discrete test section.

2. Cx Plan

The CA shall prepare a Cx Plan to clearly layout the scope, and responsibilities for successfully executing the Cx for his/her project. The Cx Plan shall be reviewed and approved by the LCA, the responsible Subject Matter Experts (SME), and the LPM.

¹⁹ NQA-1 2004 Requirement 11 provides direction for test control. See CMP 400 r0 Section 5.0 – for specific instruction on Conduct of Testing.

3. Test Procedures²⁰

The CA shall prepare detailed component and system test procedures in accordance with the level of rigor for each system, or subsystem as determined in the Graded Approach Review for the project.

The procedures shall have appropriate levels of verification signatures, witness and hold points, and test results documentation to fully comply with all code requirements invoked by the quality level and rigor of testing assigned in the Graded Approach Review.

4. Procedure Review and Approval

The system integrated test procedures shall be reviewed and approved by the LCA and the responsible SMEs.

5. Test Personnel Qualification

Test personnel qualification and competency to perform testing assigned to them by the CA must be documented. The CA may adopt and use CMP 400²¹ (*e.g.*, *Section 4.0 of rev 0*) or they may submit their own test personnel qualification procedure to the LCA for approval.

Levels of qualification and experience shall use a graduated competency scale based on the individuals' education and experience level. Task assignments shall be based upon the test personnel's level of competency. The complexity and risk of the assigned test must be taken into consideration when ensuring that test personnel are competent and fully qualified to perform the test. See Appendix A, Test Technician and Cx Agent Qualification Guidelines.

Guidance: The LCA generally requires such experience levels of techs and CAs.

B. Phases

1. Design Phase

a. Project Definition

*Guidance: For major capital acquisitions, it is helpful to the project to consult with the LCA when the project is being defined so Cx needs are understood.*²²

²⁰ CMP-400 r0 Section 3.0 provides specific instruction in the development and approval process for test procedures

²¹ CMP-400 r0 Section 4.0 follows NQA-1 2004, Part III, Non-mandatory Appendix 2A-1, Guidance on the Qualification of Inspection and Test Personnel

²² This may be required by other LANL documents (at time of writing, AP-350-420 states in Section 3.1 that Cx will be involved starting at the project definitions stage).

b. Conceptual Design

Guidance: The PE should involve the LCA with the Design Authority Representative (DAR), and Design Agency to evaluate design input documentation, prepare recommendation for method of turnover (zone, system, etc.), and develop preliminary schedule for Cx activities.

c. Preliminary Design

- i. When the engineering design is approximately 60% complete, the LCA will review the preliminary design, determine the applicability of the LANL Cx Process and this chapter, and collaborate with the LPM and the Project Team to gain concurrence and to select a CA and set preliminary Division of Responsibilities (DOR).
- ii. Once the CA is on board, they will, in collaboration with the LCA, identify and document the owner's project requirements for Cx and develop an initial approach to Cx, conduct the graded approach review and determination, and prepare a preliminary Cx Plan and DOR.
- iii. The Cx Plan will be reviewed for preliminary concurrence by the LCA, appropriate SMEs, and the LPM.
- iv. Throughout the design phase the CA and its Cx team will review and comment on design operability, maintainability, and testing readiness.

d. Final Design

As the engineering design approaches completion (90%), the CA reviews and updates the preliminary Cx documents and issues the final Cx Plan for approval. The CA shall incorporate project specific Cx requirements into the project specifications before they are issued for purchasing and construction.

2. Construction Phase

- a. As construction progresses the CA shall issue the final Cx Plan once concurrence is reached and all approvals are obtained.
- b. The CA, working with the project scheduler, shall develop schedules for Cx and incorporate the Cx schedules into the Master Construction Schedule. These schedules shall include system completion sequencing for completion and turnover to the Cx team.
- c. The CA shall develop Component and System test procedures for each system and have them reviewed and approved by the LCA and SMEs as they are prepared.
- d. As construction nears completion the construction focus shall shift to completing entire systems in accordance with the completion and turnover

schedule as documented in the Master Construction Schedule. Installation verification walkdowns shall be conducted with the CA and the Cx Team taking custody and care of the system after acceptance²³.

3. Testing Phase

- a. Testing by the Cx Team shall be in accordance with of CMP 400 section on conduct of testing (*Section 5.0 of rev 0*) or the subcontractor CA's procedure for same. The Cx Team shall execute the approved component and system test procedures, document test results and submit them for approval as required by the Cx Plan.
- b. This testing should not be confused with testing and inspections (T&I) as required by the International Building Code and as described in ESM Chapter 16, IBC Program. These tests are the responsibility of the subcontractor or LANL Building Official (LBO) as noted in that chapter.

i. Component Testing

As systems are turned over from Construction to the Cx Team component testing will begin with basic tests to determine that each component operates as intended and that it is ready to be integrated into system testing.

ii. Factory Acceptance Testing (FAT)

Many vendor systems and major components are best tested at the vendor's facility prior to shipping to avoid possible delays and added costs should a problem be found requiring a return to the factory. These factory acceptance tests (FAT) shall be witnessed by members of the Cx Team and possibly the responsible SME. The project representatives attending the FAT shall ensure that the vendor follows submitted and approved test procedures, documents all results, and that the results meet pre-determined acceptance criteria. FATs may not be substituted for system acceptance tests performed in the field.

iii. System Acceptance Testing (SAT)

System Acceptance Testing (SAT) is the testing performed in-place and in accordance with the CA's approved test procedures to demonstrate the overall functionality and performance of the system to design.

4. Turnover to the Owner

As entire systems are satisfactorily functional tested the CA shall assemble completion packages and a Final Commissioning Report for turnover to the owner. The Completion Packages and the Final Commissioning Report shall be

²³ AP-350-420, *Turnover and Acceptance* provides instruction on the conduct of walkdowns and the turnover of systems for commissioning.

turned over to the owner in accordance with PM Procedure AP-350-420, Turnover and Acceptance.

5. Project Closeout and Warranty
 - a. The CA and LCA shall provide support to the owner during transition to full operations.
 - b. Lessons learned throughout the execution of the project shall be captured at closeout by the CA and LCA to form a Lessons Learned Document for the benefit of future projects and to identify best practices.
 - c. The LCA shall provide warranty support and analysis assistance to the owner as requested.
 - d. The LCA shall provide support for seasonal testing and verification testing to meet LEED requirements or other commitments that could not be verified prior to turnover or require repeated testing during various seasonal conditions.

7.0 DOCUMENTATION REQUIREMENTS

- A. The following documents are to be prepared, approved and retained for each project executed under this standard. Additional documentation requirements may be applied in the Project Execution Plan or the Commissioning Plan.
 1. Commissioning Plan
 2. Commissioning/Test Procedures
 3. Final Test Summary Report
 4. Lessons Learned Document

8.0 APPENDICES

- A. Test Engineer Qualification Requirements

9.0 ATTACHMENTS

- A. Commissioning Process Flow Chart

Appendix A

Test Technician and Cx Agent Qualification Guidance

Level	Desired Capabilities	Desired Education and Experience
<p>I</p>	<p>Capable of performing and documenting the results of inspections and tests that are required to be performed in accordance with documented procedures, acceptance standards, and/or industry practices as defined in user’s written procedures</p>	<p>2 years of related experience in equivalent inspection or testing activities; or</p>
		<p>High school graduation and 6 months of related experience in equivalent inspection or testing activities; or</p>
		<p>Completion of college level work leading to an associate degree in related discipline plus 3 months of related experience in equivalent inspection or testing activities</p>
<p>II</p>	<p>All the capabilities of a Level I person for the inspection or test category or class in question. Additionally, have demonstrated capabilities in planning inspections and tests, in setting up tests, including preparation and setup of related equipment, as appropriate; in supervising or maintaining surveillance over inspections and tests; in supervising and certifying lower level personnel; and in evaluating the validity and acceptability of inspection and test requirements.</p>	<p>1 year satisfactory performance as a Level I in the corresponding inspection or test category or class; or</p>
		<p>High school graduation plus 3 years of related experience in equivalent inspection or testing activities; or</p>
		<p>Completion of college level work leading to an associate degree in related discipline plus 1 year of related experience in equivalent inspection or testing activities; or</p>
		<p>Graduation from a 4-year college plus 6 months of related experience in equivalent inspection or testing activities</p>
<p>III</p>	<p>All the capabilities of a Level II person for the inspection or test category or class in question. Additionally, be capable of evaluating the adequacy of specific programs used to train and certify inspection and test personnel whose qualifications are covered by this appendix.</p>	<p>6 years of satisfactory performance as a Level II in the corresponding inspection or test category or class or</p>
		<p>High school graduation plus 10 years of related experience in equivalent inspection or testing activities; or high school graduation plus 8 years of experience in equivalent inspection or testing activities (and, for nuclear work, with at least 2 years as a Level II and with a least 2 years associated with nuclear facilities, of sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility); or</p>
		<p>Completion of college level work leading to an associate degree plus 7 years of related experience in equivalent inspection or testing activities (and for nuclear work, with at least 2 years of this experience associated with nuclear facilities or at least sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility); or</p>
<p>Graduation from a 4-year college plus 5 years of related experience in equivalent inspection or testing activities (and, for nuclear work, with at least 2 years of this experience associated with nuclear facilities or at least sufficient training to be acquainted with the relevant quality assurance aspects of a nuclear facility)</p>		