commissioning program and practices guidelines

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# ACRONYMS AND ABBREVIATIONS

ALARA As Low As Reasonably Achievable

CAT Construction Acceptance Test

CG&A Calibration, Grooming and Alignment

CD-4 Critical Decision 4 (as per DOE Order 413.3B)

CSE Cognizant System Engineer

CP Commissioning Plan

CPPG Commissioning Program and Practices Guideline

DA Design Authority

DOE United States Department of Energy

DSA Documented Safety Analysis

EP Emergency Preparedness

EPC Engineering Procurement, and Construction

ES&H Environment, Safety, and Health

FAT Factory Acceptance Test

KPP Key Performance Parameters (as defined in DOE O 413.3)

ICD Interface Control Document

IP Implementation Plan

ITAAC Inspections, Tests, Analyses and Acceptance Criteria

ISMS Integrated Safety Management System

IVR Implementation Verification Review

NRC Nuclear Regulatory Commission

OAT Operational Acceptance Test

OJT On-the-Job Training

O&M Operations and Maintenance

ORR Operational Readiness Review

PCC Project Completion Criteria (as defined in DOE O 413.3)

POA Plan of Action

RR Readiness Review

R&TM Research and Technology Maturation

SER Safety Evaluation Report

SNR Startup Notification Report

USQ Unreviewed Safety Question

# PREFACE

This “Commissioning Program and Practices Guideline” (CPPG) presents a compendium of commissioning practices, references, and tools applicable to new facilities (nuclear & non-nuclear) supporting the ORP Tank Waste Remediation mission. The information provided in this CPPG may be tailored and adjusted as appropriate by users.

The guidelines presented herein are based on the authors’ search and translation of commissioning information from various available commercial and government sources. This CPPG is not a requirements document and does not endorse contractor or project specific approaches over others. The main criterion for inclusion is that an approach is judged to be “proven and/or generally accepted” based on the experience informed judgment of the authors.

This CPPG is in alignment with and complements the requirements of DOE O 413.3B, “Program and Project Management for the Acquisition of Capital Assets” and associated guides. However some aspects of the current suite of DOE requirements and guidance appear vague or incomplete regarding specific implementation elements of a comprehensive commissioning program. Examples include:

* DOE O 413.3B requires the development of a “Checkout, Testing and Commissioning Plan” but does not describe or prescribe the scope or content of such a plan
* DOE G 413.3-16A “Project Completion/Closeout Guide” provides an overview discussion of the Commissioning Plan with reference to the Portland Energy Conservation’s “Model Commissioning Plan and Guide Specification” which appears to lack adequate context for nuclear facility commissioning
* DOE-EM-SRP-2010, “Checkout, Testing, and Commissioning Plan Review Module” provides performance objectives and review criteria for a Commissioning Plan but lacks developmental guidance
* An authoritative source of commissioning definitions could not be identified in the DOE order and guides

This CPPG supplements the DOE requirements and guidance by:

* Providing a comprehensive holistic approach to commissioning benchmarked to industry best practices and underpinned by practical experience in both the government and commercial sectors;
* Offering a single source of proven/generally accepted approaches and best practices to achieve the full scope of commissioning – individual projects to decide applicability
* Informing the development and review of future commissioning strategies and plans for new facilities supporting the Tank Waste Remediation mission;
* Providing definitions of key terms relied upon to accurately communicate commissioning strategies, plans and actions. These definitions are considered necessary to provide a level of clarity and consistency for this plan that is not always provided in the DOE guidance documents;
* Fostering common understanding and integration of commissioning programs and practices among ORP and its contractors;
* Affording a “memory” for future projects (avoid re-inventing the wheel and re-learning lessons)
* Providing a living document that is periodically updated to add detail and clarifications consistent with the evolution of commissioning practices.

# DEFINITION OF TERMS

The following definitions are for use with this document only and are not intended to contravene or contradict other established definitions.

**Authorization Agreement**

A documented agreement between the DOE and the contractor for high-hazard facilities (Category 1 and 2), incorporating the results of DOE’s review of the contractor’s proposed authorization basis for a defined scope of work. The Authorization Agreement contains key terms and conditions (controls and commitments) under which the contractor is authorized to perform work. Any changes to these terms and conditions would require DOE approval.

**Authorization Basis**

Safety documentation supporting the decision to allow a process or facility to operate. Included are the facility safety basis, corporate operational and environmental requirements as found in environmental regulations and specific permits, and, for specific activities, work packages or job specific safety analyses.

**Care, Custody and Control**

Actions defined to protect structures, systems and components (SSCs) from loss or damage and to prevent degradation. Care, custody and control actions may include surveillance, maintenance and operations as specified in turnover documentation. Care, custody and control is a means to establish ownership of the SSCs in accordance with associated programs and procedures.

**Commissioning**

Commissioning is performed to demonstrate that SSCs meet or exceed established project requirements such that full facility operation and throughput can be achieved as soon as safely achievable. Commissioning is a systematic and holistic process for achieving, verifying, and documenting that the facility and its various systems and components can perform interactively to meet or exceed Key Performance Parameters (KPPs) and/or Project Completion Criteria (PCC), design requirements and mission needs. Planning for commissioning begins during the early stages of a project and the execution of commissioning actions culminates with actual verification of performance, completion of operation and maintenance documentation and the training of operating personnel. In this context, the commissioning function includes the turnover, testing and pre-operational actions required to complete the project (achieve CD-4). During commissioning, the facility is in a highly dynamic quasi operational mode.

**Commissioning Programs**

Commissioning programs are developed, approved and implemented to support specific commissioning phases and sequences (such as component or system testing using water). Commissioning programs in many cases may parallel those for post-CD 4 operations but typically do not warrant the same level of programmatic rigor or control. Commissioning programs are developed and implemented using a graded approach based on the hazards associated with the commissioning activity. The term “commissioning programs” does not imply that all of these programs are required for all commissioning activities.

**Component**

A group of like individual items or an individual item, such as a crane, valve or pump with its associated ancillary devices [i.e. instrument(s), cable(s), breaker(s), motor(s), piping and/or valving], turned over for the benefit of early testing.

**Cold Commissioning**

Testing operations to verify that the facility will perform in accordance with design specifications using water and/or chemicals and/or other non-radioactive simulated feeds (i.e. specifically developed simulant). Cold commissioning also includes the pre-operational activities necessary to implement the permits, safety programs, and interfaces required to enable the authorization of full and unrestricted hot operations.

**Construction Acceptance Testing (CAT)**

Construction Acceptance Testing (CAT) is a type of commissioning test performed by the constructor that ensures construction activities are properly performed in accordance with industry practices, codes and standards, and that the quality requirements of the contract/construction specification are met. These tests ensure the electrical and mechanical integrity of the new or modified SSCs, and ensure equipment was properly installed. Typically, CAT includes hydrostatic pressure tests, piping leak tests, electrical insulation and continuity tests, equipment alignment, motor bumps for correct rotation, and verification of component functionality.

**Construction Completion (Substantial Construction Completion)**

The status of the Project when all Construction Contractor Statement of Work items including material, construction, installation, and testing requirements for all systems, components and structures has been completed, and the facility will operate in a safe manner. Examples of general criteria for achieving construction completion includes:

* Construction Contractor has achieved mechanical completion of all SSCs
* Specified commissioning support (e.g. testing, training, etc) has been completed
* Punchlist items related to the project shall have been completed

**Energization**

The process of establishing permanent electrical power to facility transformers, buses, motor control centers and circuitry to components and equipment.

**Facility Readiness Plan (FRP)**

The Facility Readiness Plan (FRP) is an element of the operational readiness process that sets the stage for a formal structured verification of facility readiness to startup. The FRP is the assessment plan that defines what will be evaluated during the startup management self-assessment (SMSA) process. It provides personnel with vital initial information regarding the planned readiness process.

The detail must be sufficient for preparers, reviewers, and approvers to substantiate the operational readiness decisions being made. The FRP is developed using a graded approach to the tenets of the requirements specified in DOE O 425.1D, “Verification of Readiness to Start Up or Restart Nuclear Facilities.”

The FRP content depends on knowledgeable people identifying relevant topics based on their experience, the facility characteristics, operating environment, the operating and support organizations capability, and the risk associated with the proposed startup or restart.

**Factory Acceptance Testing (FAT)**

Factory acceptance testing is a type of commissioning test performed by the manufacturer/vendor at their facility, or other Hanford facilities outside the direct control of the Project, to ensure that the equipment to be supplied meets their standards of quality and the design parameters provided in the purchase specification. Examples of factory acceptance testing are: pump performance testing, 24-hour motor runs, and integrated performance testing such as for control trailers or skid mounted equipment.

**Functional Testing**

Functional testing (also known as Operational Acceptance Testing, Startup Construction Testing, System Operational Testing, etc.,) progressively demonstrates acceptable component, system and integrated system performance. Functional testing is typically performed by the commissioning organization and select O&M staff (i.e. operators and maintenance craft). The scope of functional testing typically includes the following:

* Component testing
* Discrete system testing
* Integrated system testing

Functional testing ultimately results in the objective evidence that demonstrates the facility SSCs are correctly installed and are functioning as designed using the control system and any associated Safety Instrumented Systems (SIS) and alarms.

**Hot Commissioning**

The processing of a minimal acceptable sample of an actual material to obtain the desired performance output during the startup and testing phase of a chemical or nuclear processing facility. Hot commissioning includes those tests and performance trials not practical during other commissioning phases (such as confirmation of shielding effectiveness).

Nuclear operations conducted in accordance with the provisions of the startup plan following successful completion of a readiness review as authorized by the Startup Approval Authority. Initially, the sequence of deliberate operations and oversight identified in the startup plan is followed and a controlled quantity of radioactive feed is processed until proficiency has been gained and the hold points of the startup plan have been met, at which time full and unrestricted operations may be appropriate.

**Hot Operations**

Unrestricted radioactive facility operations, typically following execution of the start up plan.

**Implementation Verification Review (IVR)**

A formal independent verification of the completeness and adequacy of the implementation of the safety basis (DSA and TSRs) for a nuclear facility. A successful IVR, including the resolution of all pre-start issues, may be a prerequisite to the start of a Readiness Review (RR) as defined in DOE O 425.1D, “Verification of Readiness to Start Up or Restart Nuclear Facilities.”

**Inspections, Tests, Analyses and Acceptance Criteria (ITAAC)**

The ITAAC process is based on a similar U.S. Nuclear Regulatory Commission (NRC) program. This process minimizes rework, maximizes schedule efficiency and tracks readiness criteria to completion. This process identifies the inspection and testing requirements and acceptance criteria using a graded approach, for each component, subsystem, system and facility; forms the foundation for test plan development; and ensures that installed systems will function as intended. The ITAAC is implemented via test program procedures and drives the development of test specific requirements.

**Maintenance Trials**

Maintenance trials are demonstrations to prove the maintainability of process equipment and validate the maintenance procedures. Trials are performed as soon as possible so that any maintenance issues can be identified early, thereby minimizing the impact on the commissioning process. Trials can be completed in conjunction with the appropriate testing phase rather than being conducted as a separate activity.

**Mechanical Construction Completion**

The stage reached during the assembly of a component, system, or within the physical boundary of an area when the construction phase has been substantially completed. Mechanical completion is achieved when construction is in conformance with drawings and specifications with the exception of items identified for resolution on a punchlist. Mechanical completion is typically confirmed by completion of Installation Checklists, Construction Verification Tests and Construction Acceptance Tests. Mechanical construction completions is a prerequisite to system or facility turnover.

**Measuring and Test Equipment (M&TE)**

Tools, gauges, instruments, devices, or systems used to inspect, test, calibrate, or measure quality parameters and data. M&TE devices may include permanently installed facility process or control instrumentation. M&TE is calibrated using certified equipment or reference standards having verifiable relationships to the National Institute of Standards and Technology (NIST) or other national consensus standards. Where no such standards exist, the basis for calibration shall be documented and retrievable. M&TE calibration records shall be traceable to the certified equipment or standard used to perform the calibration.

**Performance Trials**

Performance trials are demonstrations to prove the operability, maintainability and inspectability of select SSCs. The SSCs selected for performance trials are typically based on criteria such as short mean time to failure or long mean times to repair as determined by analysis of Operational Research Model results or historical records of performance. Some types of performance trails (see specific definitions) include:

* Maintenance
* Remotability
* Safety and Environmental

**Plan of Action (POA)**

The document prepared by line management that describes the scope of the RR, the prerequisites to be met to begin the RR, and the proposed Team Leader for the RR.

**Pre-Operations (Pre-Ops)**

The planning, preparation and implementation of programs and procedures and the training of personnel necessary to achieve and sustain operations. Pre-Ops actions and responsibilities typically include:

* Implementation of the Authorization Basis (i.e., Documented Safety Analysis, Safety Management Programs (SMPs) and Environmental Permits),
* Development and validation of operations and maintenance procedures,
* Achieving proficiency of operations and maintenance personnel through training, mockups and performance trials
* Development of the Transition to Operations Plan
* Planning and preparation for Readiness Review activities and;
* Achieving and validating operational readiness

**Readiness Review (RR)**

A review conducted to determine readiness to start up or restart a nuclear facility, activity, or operation. There are two types of RRs defined in DOE O 425.1D: Operational Readiness Reviews (ORRs) and Readiness Assessments (RAs).

**Remotability Trials**

Remotability trials are demonstrations to prove the ability to perform tasks, operate equipment, and conduct hands-off maintenance in areas where radiological or other hazardous conditions prevent human entry or hands-on work and validates the remote handling procedures. Remotability trials include using the cranes, manipulators and other remote tools to verify fit, trunnion guide and pin engagement, lifting yoke engagement and handling, setting the vessels, pumps, and other major equipment, landing of jumpers on flanges or nozzles, installation of flex jumpers and replacement/repair of jumper appurtenances (e.g. gaskets/seals, fingers/bolts). These trials are performed as soon as possible so that any issues can be identified early, thereby minimizing the impact on the commissioning process. These trials can be completed in conjunction with the appropriate testing phase rather than being conducted as a separate activity.

**Safety Basis**

The safety basis is the documented safety analysis and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public and the environment. The safety basis includes the DSA, TSRs, Safety Evaluation Reports, and other documents identified by ORP in Safety Evaluation Reports as relied upon to approve changes.

**Safety and Environmental System Trials**

Safety and Environmental System trials are demonstrations to prove that nuclear safety and environmental compliance related components meet their performance requirements. These trials may require the use of surrogate inputs to demonstrate functionality. Trials are performed as soon as possible so that any issues can be identified early, thereby minimizing the impact on the commissioning process. Trials can be completed in conjunction with the appropriate testing phase rather than being conducted as a separate activity.

**Scoped Commissionable System**

A defined group of mechanical/electrical components and interconnecting piping/cabling that has been identified as a logical group for testing corresponding to a commissionable (testable) system. Scoped systems are defined by the project based on design media, safety documentation and technical judgment.

**Startup**

The process of deliberate, controlled operations the contractor intends to follow after authorization to start nuclear operations following a RR.

**Startup Plan**

The management plan developed by the responsible contractor that describes the process of deliberate, controlled operations the contractor intends to follow after authorization to start nuclear operations following a RR. Suggested content is provided in DOE-STD-3006-2010, “Planning and Conducting Readiness Reviews.”

**System and Subsystem**

A system is a group of mechanical, electrical, and/or process control elements designed to perform a specific operating function within a facility. A subsystem is a part of a system that can be physically isolated, scoped, and turned over to support testing activities. For the purposes of this document, system and subsystem are used interchangeably and have the same meaning

**Technology Readiness Level (TRL)**

TRL indicates the maturity level of a given technology. The TRL scale ranges from 1 (basic principle observed) through 9 (total system used successfully in project operations). TRL 7 requires demonstration of an actual system prototype in a relevant environment. Examples include testing full-scale prototype in the field with a range of simulants in cold commissioning. Supporting information at TRL 7 includes results from the full-scale testing and analysis of the differences between the test environment, and analysis of what the experimental results mean for the eventual operating system/environment. Final design is virtually complete. Typically, all technologies achieve TRL 7 (full-scale, similar (prototypical) system demonstrated in relevant environment) prior to CD-4.

**Transition to Operations Plan (TOP)**

A Project Transition to Operations Plan (TOP) clearly defines the basis for attaining initial operating capability, full operating capability, or project closeout, as applicable. The plan includes documentation, training, interfaces, and schedules.

The TOP is a prerequisite to obtain Secretarial Acquisition Executive (SAE) and/or Acquisition Executive approval for CD-4. The purpose of the TOP is to identify and plan for project transition phase activities that are required for approval to begin initial or full operations of project deliverables. The overall goal is to ensure a smooth turnover of the project deliverables (i.e., equipment, facility, product, or asset) and a seamless hand-off of responsibility/ownership from the project organization to the user/operating organization. A TOP is prepared to ensure efficient and effective management of the transition scope; align schedules, identify resources to facilitate project transition; and provide proper customer/sponsor/stakeholder interfaces.

A TOP is an agreement between the Federal Project Director, DOE program, and the user/operating organization that describes the process for implementing transition to operations activities. Systems engineering techniques should be applied when developing and implementing the TOP. Guidance regarding topical considerations is identified in DOE G 413.3-16A, “Project Completion/Closeout Guide.”

**Turnover**

Turnover is the systematic and formal process of transferring full care, custody and control of an SSC or entire facility from one organizational entity to another.

**Turnover Boundary**

A turnover boundary depicts a system or component that has been scoped to support testing and turnover activities. Each turnover boundary should be assigned a unique scoped system number.

# 1.0 INTRODUCTION

This Commissioning Program and Practices Guideline (CPPG) presents a holistic and phased approach to commissioning. The central objective of a commissioning program is to deliver a plant capable of safe, compliant, efficient and sustained operations to the operations organization. This objective is achieved through integrated testing and preparation of plant systems, programs and personnel as conceptually depicted in Figure 1.

**Figure 1. Achieving a Fully Commissioned Plant**



## 1.1 BACKGROUND

A phased approach to implementation of commissioning is offered in this CPPG as a means to accomplish the central objective of a commissioning program. A phased approach is in alignment with the DOE O 413.3B project phases and Critical Decisions (CDs). The subsequent sections of this CPPG provide an overview of the phased commissioning approach. Implementation of this CPPG is supported by supplementary detailed topical guidelines modules.

The topical guidelines modules are derived or adapted from accepted practices described in a variety of sources such as the DOE-EM-SRP-2010 (Standard Review Plan for Checkout, Testing, and Commissioning Plan Review Module), DOE-G-413.3-16A (Project Completion/Closeout Guide), DOE-STD-1189-2008 (Integration of Safety into the Design Process), TOC commissioning procedures and programs, the Salt Waste Processing Facility Commissioning Plan and other commercial and government sources.

Implementation of the approaches described herein are intended to be tailored, adjusted and appended, as necessary to meet the needs of individual projects and to be in compliance with project specific procedures.

## 1.2 COMMISSIONING PROGRAM OBJECTIVES

The intended outcome of the commissioning program is to achieve the following objectives:

* Process and facility performance meeting or exceeding project requirements (KPPs and PCCs)
* Adequate and correct procedures and safety limits developed and implemented for operating the process systems and utility systems.
* Training and qualification (T&Q) programs for operations and operations support personnel are established, documented, implemented, and encompasses the required range of duties and activities.
* Safety and environmental compliance documentation is in place and describes the safety and environmental compliance basis.
* Program(s) are in place to confirm and periodically reconfirm the condition and operability of safety systems, including important to safety process systems and safety related utility systems.
* Processes are established to identify, evaluate, and resolve deficiencies and recommendations made by DOE oversight groups, official review teams, and audit organizations.
* Management programs are established, sufficient numbers of qualified personnel are provided, and adequate facilities and equipment are available to support those functions required for commissioning. These activities shall continue through to the turnover to operations.
* Functions, assignments, responsibilities, and reporting relationships are clearly defined, understood, and effectively implemented with line management responsibility for control of safety.
* Systems and procedures, as affected by facility modifications, are consistent with the description of the facility, procedures, and accident analysis included in the safety basis.
* Modifications to the facility have been reviewed for potential impacts on procedures, training, and qualification. Procedures have been revised to reflect these modifications and training has been performed to these revised procedures.
* The design documentation is complete
* The facility has been turned over to operations
* A Readiness Review has been successfully completed.

## 1.3 PHASED COMMISSIONING MODEL

Figure 2 depicts an example of a linear and logically sequenced model of typical commissioning activities and project phases as interpreted from DOE O 413.3. In practice, the alignment of commissioning activities to project phases may not follow a “typical” or “standard” model. Therefore the Figure 2 model can and should be adjusted as necessary to accommodate streamlined or tailored approaches such as combining CD activities (e.g. CD 2/3 for accelerated procurement/construction)

**Figure 2. Example Phased Commissioning Model**

**CD-4**

**(PROJECT COMPLETION AND APPROVAL TO INITIATE OPERATIONS)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **PROJECT DEFINITION & CONCEPTUAL DESIGN (30%)** | **PRELIMINARY DESIGN (60%)** | **FINAL DESIGN (90%)** | **PROCUREMENT AND CONSTRUCTION** | **COLD COMMISSIONING** | | | **HOT COMMISSIONING** |
| CD-1 | CD-2 | CD-2 | CD-3  Acceptance Testing | CD-3  Functional Testing  (Component & Discrete System) | CD-3 Functional Testing  (Integrated Systems) | CD-3  Functional Testing  (Integrated Facility) | Post CD-4  Hot/Active Testing  (Transition to Operations) |
| * Cx team input to alternatives & proposals * Input to cost & schedule range development * Outline Cx strategy * Develop and communicate testing strategy * Develop Cx Specifications for A/E & Constructor * Identify Cx data & information management approach (e.g. SmartPlant) | * Integrate Cx interfaces, logic and milestones with project schedule * Refine Cx cost estimate * Issue Cx Plan * Draft turnover plan * Draft test plans for construction phase * Commissionability & testability design reviews * Define/review initial FAT requirements * Establish Testing Oversight (JTG) * Define ITAAC and initial TR * Initiate Pre-Operations Planning | * Finalize Cx cost & schedule inputs * Finalize TR * Design reviews to confirm inclusion of Cx features in design * Finalize turnover plan * Revise and finalize FAT requirements * Review and integrate R&TM results into Cx planning * Update Cx Plan, implementing procedures and test plans * Initiate design of O&M training * Draft TOP | * FAT (performed by vendors at vendor facilities) to ensure procurement specifications are met * CAT (performed by construction forces) to ensure component level requirements are met * Review FAT/CAT results * Initial development of operations procedures * Procurement of equipment and spares for Cx. * Initiate readiness planning * Complete formal turnover(s) of SScs to Cx team for care, custody and control | * Progressively complex testing of components and systems with water as test fluid – * Testing conducted by O&M staff to complement training and establish proficiency * Care, Custody and Control by Commissioning organization * Implement Commissioning Programs * Initiate O&M procedure development and validation * Resolution of Construction punchlist items | * Integrated systems testing progresses to integrated water runs/testing * Issue System/Subsystem Documents * In-situ performance trials * Establish operator proficiency * Issue TOP * Install modifications to enable introduction of simulant * Complete construction punchlist closure * Complete readiness for chemical and simulant tests | * Cold chemical/simulant tests * Final in-situ performance trials * Final validation of Ops procedures * Full “mock hot operations” in conjunction with SMP implementation * Confirm operator proficiency * Readiness achieved and validated for Hot Ops * Issue Startup Plan * Complete Contractor/DOE RR * All technology achieves TRL-7 | * Close Post Start Punchlist/Findings * Implement Startup Plan * Perform Hot Ops transition testing (e.g. Shielding, Process Capacity, Environmental, etc) * Implement TOP - achieve authorization for unrestricted operations * Prepare Final Cx reports |

**MECHANICAL COMPLETION AND TURNOVER TO COMMISSIONING**

**60% DESIGN COMPLETE**

**START CD-3**

**CD-1 COMPLETE**

**START CD-2**

Prepare & Issue Cx Plan

Facility Construction

Construction Punchlist Item Resolution & Closure

Component & System Functional Testing

Integrated System Functional Tests

Integrated Facility Functional Testing

Turnover Planning and Implementation

Achieve & Validate Readiness to Commence Chemical & Simulant Testing

CRR & DOE-RRs

DOR

Achieve & Validate Readiness to Commence Hot Operations

Operational Readiness Planning

Execute Startup Plan & Implement TOP

Pre-Operations Planning and Execution

Acceptance Testing

**KEY TO TERMS AND ABBREVIATIONS**

**Cx** – Commissioning

**CRR** – Contractor Readiness Review

**DOR** – Declaration of Readiness

**DOE-RR** – DOE Readiness Review

**ITAAC** – Inspection, Tests, Analyses and Acceptance Criteria

**JTG** – Joint Test Group

**O&M**–Operations and Maintenance

**RR** – Readiness Review

**R&TM** – Research and Technology Maturation

**SMP** – Safety Management Program

**Test Result** – Any result from any type of test

**TOP** – Transition to Operations Plan

**TR** – Test Requirements

**ACTIVITY BARS ARE INDICATIVE AND NOT TO SCALE**

# 2.0 COMMISSIONING PROGRAM FUNCTIONS

A comprehensive commissioning program and implementing plan(s) should consider incorporating the following key programmatic functions or aspects thereof as a means to organize the technical work scope:

* Testing
* Operations
* Commissioning Support

An example work breakdown structure for these key functions is provided below. The subsequent Sections describe general work scope and typical roles and responsibilities consistent with implementing the example work breakdown structure.

Each project should evaluate and implement the appropriate elements of a similar work breakdown structure and the associated organizational arrangements.



## 2.2 TESTING

Discuss general work scope and typical roles and responsibilities associated with this function as per the example work breakdown structure.

## 2.3 OPERATIONS

Discuss general work scope and typical roles and responsibilities associated with this function as per the example work breakdown structure.

## 2.4 COMMISSIONING SUPPORT

Discuss general work scope and typical roles and responsibilities associated with this function as per the example work breakdown structure.

# 3.0 COMMISSIONING TECHNICAL SCOPE

This section outlines the commissioning technical scope for a project in alignment with typical DOE O 413.3 project phases (walkthrough of Figure 2). The topical modules will provide detailed guidelines to accomplish the scope.

## 3.1 DESIGN PHASE (CD-1 and CD 2)

This section to provide summary discussion consistent with Figure 2 (details to be provided in referenced modules) of typical items to include or consider for the following:

* Operability Reviews
* Testability reviews
* Definitions of scoped (testable/commissionable) systems
* Review and integrate Research & Technology Maturation results into commissioning planning
* Commissioning specifications for A/E and constructor
* Develop Commissioning Plan
* Initial Transition to Operations Plan
* Etc.

## 3.2 PROCUREMENT AND CONSTRUCTION PHASE (CD-3)

This section to provide summary discussion consistent with Figure 2 (details to be provided in referenced modules) of typical items to include or consider such as :

* Acceptance Testing
  + Factory Acceptance Testing (FAT)
  + Construction Acceptance Testing (CAT)/Energization
* Construction Completion/Turnover to Commissioning

## 3.3 COLD COMMISSIONING PHASE (CD-3 to CD-4)

This section to provide summary discussion consistent with Figure 2 (details to be provided in referenced modules) of typical items to include or consider such as :

* Functional Testing
  + Component
  + Discrete System
  + Integrated Systems
    - Water Runs
  + Integrated Facility
    - Chemical Runs
    - Simulant Runs
    - Performance trials
    - Mock-active
    - Etc.
* Pre-Operations
  + Operational Readiness
  + Authorization Basis Implementation
  + Develop and Finalize TOP
  + Training
  + Procedure Development

## 3.4 HOT COMMISSIONING PHASE (Post CD-4)

This section to provide summary discussion consistent with Figure 2 (details to be provided in referenced modules) of typical items to include or consider such as:

* Implement Startup Plan
* Hot/Active Testing
  + shielding performance confirmation,
  + production capacity,
  + environmental performance confirmation,
  + etc.
* Implement Startup Plan
* Implement TOP

# 3.0 SOURCES

Such as:

1. 10 CFR Part 830, “Nuclear Safety Management”
2. DOE-EM-SRP-2010, “EM Standard Review Plan Checkout, Testing, and Commissioning Plan Review Module,” 2nd Edition.
3. DOE G 413.3-4A, “Technology Readiness Assessment Guide”
4. DOE-G-413.3-16A, “Project Completion/Closeout Guide”
5. DOE G 423.1-1B, “Implementation Guide for Use in Developing Technical Safety Requirements”
6. DOE G 450.4-1B, Volume 1, “Integrated Safety Management System Guide (Volume 1) for use with Safety Management System Policies (DOE P 450.4, DOE P 450.5, and DOE P 450.6); The Functions, Responsibilities, and Authorities Manual; and the DOE Acquisition Regulation”
7. DOE M 450.4-1, “Integrated Safety Management System Manual”
8. DOE O 413.3B, “Program and Project Management for the Acquisition of Capital Assets”
9. DOE-O 420.1B, “Facility Safety,”
10. DOE O 422.1, “Conduct of Operations”
11. DOE O 425.1D, “Verification of Readiness to Start Up or Restart Nuclear Facilities”
12. DOE O 426.2, “Personnel Selection, Training, Qualification, and Certification Requirements for DOE Nuclear Facilities”
13. DOE O 433.1B, “Maintenance Management Program for DOE Nuclear Facilities”
14. DOE-STD-1189-2008, “Integration of Safety Into the Design Process”
15. DOE-STD-3006-2010, “Planning and Conducting Readiness Reviews”
16. Portland Energy Conservation, Inc. (PECI), “Model Commissioning Plan and Guide Specifications,” Version 2.05
17. U.S. Army Corps of Engineers, ER 110-345-723, “Systems Commissioning Procedures”
18. BNFL Inc., BNFL-5232-CP-01-Rev2, “Idaho National Engineering and Environmental Laboratory Advanced Mixed Waste Treatment Project Commissioning Plan”
19. 24590-WTP-PL-COPS-15-0005, Rev. A, “Commissioning Plan”
20. P-SUP-J-00001, Rev 0., “Salt Waste Processing Facility Project Commissioning Plan”
21. 24590-WTP-PD-RACT-TA-0001, Rev 0, “Commissioning Turnover and Transition Program Description”

# APPENDIX A – BIOGRAPHIES

Biographies to demonstrate authors are sufficiently experienced/qualified to prepare this CPPG

# MODULE A – HAZARDS & CONTROLS

Module guideline elements to include:

* Commissioning hazards identified, analyzed and controlled in accordance with ISMS
* Analysis approach (such as AJHA or similar)
* General Industrial and Chemical safety principles
* Safety Inspections during commissioning (example checklist)
* General dynamic hazards and controls discussion (see figure below or similar concepts)



# MODULE B –DESIGN PHASE ACTIONS

Module guideline elements to include:

* Design review checklist examples for testability and operability reviews
* RT&M integration considerations
* Considerations and examples for scoped (testable/commissionable) systems
* Cx specification example for A/E and constructor
* Commissioning Plan Outline example
* TOP outline example
* Startup Plan example

# MODULE C – INFRASTRUCTURE

Module guideline elements to include:

* Administrative programs and procedures
* Materials, Equipment and Services
  + Spares
  + Consumables
* Temporary infrastructure examples

## C.1 ADMINISTRATIVE PROGRAMS AND PROCEDURES

This module element describes the programs and procedures needed to support commissioning activities. These programs and procedures are developed, approved and implemented to support specific commissioning phases and sequences (such as component or system testing using water). A graded approach is applied based on the hazards associated with the commissioning activity. The term “commissioning programs” does not imply that all of these programs are required for all commissioning activities.

Examples of commissioning programs and procedures are outlined in the table below:

|  |  |  |
| --- | --- | --- |
| Program Area | Example Implementing Procedure(s) | Samples of Suggested Scope |
| Safety | Hazard Analysis | Describes hazard analysis process(es) for commissioning activities and maintenance. |
|  | Industrial Safety and Hygiene | Addresses topics specific to commissioning activities such as applications and proper use of PPE, lifting and handling, chemical safety, ladder safety, housekeeping and assessment checklists (example checklists). |
|  | Fire Prevention and Barrier Control | Describes fire prevention requirements such as combustible controls, fire watches, etc. Describes measures that must be in place to control temporary modification of any protected escape routes or compartment/boundaries to support commissioning activities. Provides guidance for requesting, approving, authorizing, performing, monitoring and re-instating of any temporary modifications of the fire systems/boundaries. |
|  | Confined Space Control for Commissioning Access | Addresses controls, authorizations and responsibilities for entry to a confined space established by design. Defines process for authorizing, establishing and controlling temporary confined spaces for access only to support commissioning. Provides list of established/defined confined spaces. |
|  | Emergency Response | Defines emergency conditions, responses, notifications, communications and authorities during commissioning. |
| Maintenance | Work Authorization and Control |  |
|  | Maintenance for Commissioning (Preservation Maintenance) |  |
|  | Commissioning Materials, Services and Spares Identification, Procurement and Control |  |
|  | Control of M&TE |  |
| Configuration Management | Control of Temporary Commissioning Modifications |  |
|  | Interface Control During Commissioning |  |
|  | Development and Control of Commissioning Aid Documents (e.g. commissioning P&IDs, waste handling flowsheets, etc.) |  |
|  | Production and Control of Commissioning Documents and Objective Evidence |  |
|  | Turnback for Construction Rework |  |
|  | Lockout/Tagout |  |
|  | Scoping | Describes the methodology for scoping systems and provides direction for the preparation, use, and control of scoped drawings. |
|  | Work Boundary and Access Control |  |
|  | Software Modifications for Programmable Systems |  |
|  | Hardware Change Control for Programmable Systems |  |
|  | Identification, Tracking and Closure of Test Deficiencies |  |
|  | Turnover | Establishes the requirements and methods for turnover of components, systems or areas. |
|  | Short and Long-Term Layup | Provides a technical overview of the methods approved for equipment and system lay-up following testing completion, suspensions or interruptions. |
| Testing and Performance | Conduct of Testing and Performance Trials |  |
|  | Identifying and Defining Performance Trial(s) |  |
|  | Supporting and Witnessing Construction Testing (FAT/CAT) |  |
|  | Test and Trials Plan Preparation |  |
|  | Test and Trials Procedure Preparation |  |
|  | Test Results Report Preparation |  |
|  | Test Results Evaluation and Review |  |
|  | Testing Practices |  |
|  | Test Review and Control (e.g. JTG, JTWG) |  |
|  | Recommended Test Equipment | Provides a compilation of test equipment that could be needed by commissioning personnel. |
|  | Progress Reporting | Establishes the minimum requirements for progress reporting and the guidelines for preparing these reports and associated performance metrics. |
|  | Waste Management |  |
| Training | Qualification of Commissioning Personnel |  |
|  |  |  |
| Readiness | Startup Notification Report Preparation |  |
|  | Plan of Action Preparation |  |
|  | Achieving Readiness Process |  |
|  | Readiness Self-Assessment Process |  |
|  | Startup Plan Preparation |  |
|  | Readiness Review Support |  |
| Etc. | Etc. |  |
|  |  |  |

## C.2 MATERIALS, EQUIPMENT AND SERVICES

This module element to discuss/describe typical needs for materials, equipment and services. Consider table concept similar to that below (**what** is needed) and include discussion on **why** each item may be needed with examples of specific application:

|  |  |
| --- | --- |
| **Common Materials & Equipment** | **Common Services** |
| Portable Fire Extinguishers | Waste Disposal |
| Waste Containers | General Services (fire, emergency, security, IT, etc) |
| Radios | Training |
| Cameras | Laundry |
| Radiation Sources | Medical Services |
| Storage Cabinets | Analytical Services |
| Laundry | Speciality Engineering and Technical Support Subcontracts |
| PPE (Hard Hats, Gloves, Goggles/Face Shields, Acid Suits, etc.) | Temporary Facilities (storage, fabrication, repair, etc.) |
| Safety Equipment (Locks, Tags, etc.) | M&TE Calibration Services |
| Ladders |  |
| Hoists |  |
| Forklifts |  |
| Computers/Laptops |  |
| Extension Power Cords |  |
| Ion Exchange Resin |  |
| Portable Flush Dolly |  |
| Portable/Temporary Power Supplies |  |
| Commissioning Spares |  |

# MODULE D – TURNOVER, TRANSITION AND WORK BOUNDARY CONTROL

This module guideline element to include a discussion of key turnover and transition points and key predecessor activities consistent with the example figure below or similar concept.



Module to also include discussion of approaches to safe establishment and maintenance of work boundaries such as.

* Lock & Tag
* Physical Boundary Controls (e.g. locked doors, roped areas, etc)
* Administrative Boundary Controls (e.g. tagging approaches )
* Communication of changes

# MODULE E – INFORMATION MANAGEMENT

Commissioning will generate large volumes of technical documents, reports and records to control and document commissioning activities to ensure compliance with design, safety, regulatory and quality standards. This module to discuss and describe:

* Objective evidence quality standards and examples
* Tools and approaches for control and tracking of large numbers of documentation items – electronic document tracking and control systems for commissioning (e.g. smart plant integration)
* Change management and tracking of changes
* Concepts depicted in figure below (or similar)



# MODULE F – INTERFACE MANAGEMENT

This module to discuss development and implementation of interface management methods during commissioning such as:

* Internal Interfaces
  + Between the commissioning organization and other project and project support organizations
  + Inter-system and Inter-area
  + Inter-disciplinary
  + Between constructor and commissioning at turnover
  + Between constructor and commissioning during remedial work
* External Interfaces
  + Between the project plant and other plants/organizations
* **Internal Interfaces**
  + Discuss typical project internal functional interfaces - develop and discuss schematic similar to that below



* + Discuss inter-commissioning interface management (develop schematic) such as:
    - Inter-system
    - Inter-area
* **External Interfaces** – Discuss describe potential interfaces external to project - develop and discuss schematic similar to that below



* **Interface Analysis and Control** 
  + Interface Control Document considerations
  + Interface analysis and implementation control tools and techniques (e.g. Interface Matrix)
  + Etc.

# MODULE G – TESTING

## G.1 TEST REQUIREMENTS DEFINITION AND CONTROL

Module guideline elements to include discussion of:

* NRC based ITAAC approach to test requirements definition and flowdown to test procedures
* sources of test requirements
* structure/content of a good/well developed test requirement
* Diagram below or similar concept.



## G.2 CONDUCT OF TESTING PRINCIPLES

This module presents uniform and controlled principles, guidelines and examples for ensuring that testing activities are carried out in a safe and effective manner.

General areas for discussion include:

* Performing Tests
* Maintaining and controlling test documentation,
* Implementing test holds and restarts,
* Performing retests,
* Recording and resolving test deficiencies, and
* Encountering an emergency or abnormal condition.

## G.3 TESTING PRACTICES AND GUIDELINES

Module guideline elements to include:

* Planning and implementation guidelines for each test stage and associated type of test
* General methods and guidelines for inspecting and testing various equipment/system types such as:
  + control systems & software,
  + pumps,
  + valves,
  + heat exchangers
  + fluidic devices
  + HVAC equipment and systems
  + Air and vacuum equipment and systems
  + etc

# H PERFORMANCE TRIAL PRACTICES AND GUIDELINES

Module guideline elements to include:

* Requirements definition and control
* Principles for conduct of performance trials
* Performance trials practices and guidelines

## H.1 REQUIREMENTS DEFINITION AND CONTROL

Discuss sources of requirements for demonstrations such as

* OR model,
* Design review
* Vendor manuals,
* Experience,
* FMEA or other analysis
* Regulatory Permits
* Safety Documents
* Hazard Analysis
* Etc.

## H.2 PRINCIPLES FOR CONDUCT OF PERFORMANCE TRIALS

Similar to conduct of testing

## H.3 PERFORMANCE TRIALS PRACTICES AND GUIDELINES

General methods and guidelines and examples of types of performance trials for equipment and systems such as:

* Maintenance trails
  + Remotability
* Production capacity/OEE trials
* Environmental system trials
* Safety system trials
* Etc.

Include decision tree similar to example below:



# MODULE J – PRE-OPERATIONS

Module guideline elements to include:

* Pre-Operations development and implementation
* Operational Readiness
* Transition to Operations Planning

## J.1 PRE-OPERATIONS DEVELOPMENT AND IMPLEMENTATION

Guidelines will include discussion of the planning and preparations necessary to develop and implement the PreOps programs. Specific areas for discussion to include:

* Authorization Basis (emphasis on safety basis implementation)
* Implementation of Safety Management Programs (SMPs) identified in Title 10, Code of Federal Regulations, Part 830, "Nuclear Safety Management", Subpart B, "Safety Basis Requirements" as follows:
  + Quality Assurance;
  + Procedures;
  + Maintenance;
  + Personnel Training;
  + Conduct of Operations;
  + Emergency Preparedness;
  + Fire Protection;
  + Waste Management;
  + Radiation Protection; and
  + Criticality Safety

## J.2 OPERATIONAL READINESS

Guidelines to describe the planning and preparations required to achieve and verify readiness for startup of LAWPS hot operations in accordance with DOE O 425.1D, “Verification of Readiness to Start Up or Restart Nuclear Facilities,” and the corresponding implementing standard DOE-STD-3006-2010, “DOE Standard – Planning and Conducting Readiness Reviews. Specific topics to include:

* Readiness Planning
  + Startup Notification Report (SNR)
  + Plan of Action (POA)
  + Facility Readiness Plan
  + Schedule and cost metrics
  + Readiness Logic
  + Startup Plan
* Achieving Operational Readiness
  + Tools and Approaches
    - checklists
    - Interface analysis
* Validating Readiness
  + Self-Assessment
* Verifying Operational Readiness
  + Contractor Readiness Review
  + DOE Readiness Review

## J.3 TRANSITION TO OPERATIONS PLANNING

Discuss development/outline of TOP in accordance with DOE guide 413.3-16A

# MODULE K – COST, SCHEDULE AND RISK CONSIDERATIONS

This section to discuss available parametrics such as:

* Commissioning costs and risk as a function of capital costs
* Commissioning duration/schedule risk as a function of
* Scope of construction testing (e.g. will it include I/O checks, bumping motors, etc.)
* Number of Panels, MCC,s etc. any panels common with other systems
* Control system complexity
  + Descriptions of hardware proposed by system, number of PLC’s etc
  + Number of I/O per system
    - Number analog
    - Number digital
    - Number and type of instruments
  + Number of sequences or if not available number of discrete operations expected to be carried out per system
* Equipment listing by system, pumps, fans, valves, cylinders, specialty equipment

# MODULE L – TRAINING

This module to discuss a phased/tailored approach to commissioning training for:

* Commissioning Team (e.g. test engineers, test directors, commissioning managers, commissioning administrative and support personnel, etc)
* O&M Team (managers, supervisors, operators, maintenance craft, etc)

The phased approach should consider the need for just-in-time training required to support each test stage or commissioning phase

This module will be based on application of the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model shown below to deliver training common to both groups as well as that specific to one group or the other considering the following needs:

* **General Training:** Training common to both commissioning and operations. Includes introductory training regarding the project and key unit operations and equipment and overview of hazards and controls. General training proactively monitored for changing project conditions and updated whenever necessary.
* **Commissioning Team Training:** Specific training provided to enable members of the commissioning team to perform field tasks specific to the project. Typical examples might include areas like the operation of specific and specialized machinery.
* **O&M Team Training:** Encompasses all new or modified plant and equipment that must be operated or maintained as part of the project facility. Training should cover the processes as well as the machine operation in both local and automatic control modes.

ADDIE Process



# MODULE M – LESSONS LEARNED

This module to provide a collection of lessons learned linked to the applicable commissioning phase or activity in the form of a matrix. Lessons learned, identified on the matrix can be considered and incorporated into the planning for the applicable commissioning phase. See example concept below:

|  |  |  |
| --- | --- | --- |
| Commissioning Phase | Lesson | Applicability |
| Design |  |  |
|  |  |  |
|  |  |  |
| Procurement & Construction |  |  |
|  |  |  |
|  |  |  |
| Cold Commissioning |  |  |
|  | HVAC systems have a history of being difficult to test and balance if significant latent design issues are discovered. For example, the HVAC system for one high hazard facility required 5 years to commission due to late discovery of design issues. | Objectively assess the complexity of the HVAC system(s) and include schedule and cost contingencies. |
|  |  |  |
| Hot Commissioning |  |  |
|  |  |  |
|  |  |  |