

INDEPENDENT OVERSIGHT OF COMMISSIONING IN NUCLEAR NEW BUILD PROJECTS



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1. Introduction

Background

The current world nuclear industry has relatively few examples of ongoing NPP new build construction projects and therefore few active examples of commissioning efforts. As the international community begins again to seriously consider nuclear new build projects, it is clear that a knowledge and experience gap in all phases of nuclear construction and commissioning exists. This gap is impactful for all new build projects but especially true in countries with no previous nuclear experience. These projects and all new builds will benefit from a rigorous commissioning oversight process to ensure industry standards of safety, nuclear and industrial, are achieved.

This document proposes a foundation for a robust NPP program of fulfilling the owner’s accountability and responsibility to provide effective oversight of plant commissioning for plant startup and longer term, day to day operations. This report focuses on crucial elements of a newly formed commissioning oversight process incorporating lessons learned from previous efforts, as well as implementing applicable aspects of Independent Nuclear Safety Oversight (INSO) identified as best practices.

Purpose

Provide a strategy and framework for a commissioning oversight program that can be applied to any new build nuclear power project. Identify crucial elements of commissioning oversight that can be employed to ensure success of the NPP commissioning program.

2. References

- a) Advanced Nuclear Technology: Startup Program Guideline—Lessons Learned. EPRI, Palo Alto, CA: 2011. 1023005
- b) IAEA Safety Standard No. SSG-28 Commissioning for Nuclear Power Plants, International Atomic Energy Agency, Vienna, 2014
- c) IAEA Nuclear Energy Series No. NP-T-2.10 Commissioning Guidelines for Nuclear Power Plants, Vienna, 2018
- d) WANO New Unit Assistance Working Group, Roadmap to Operational Readiness revision 1, 2022
- e) WANO Pre-Startup Performance Objectives and Criteria, PO&C 2013-02 Rev.1, 2024.

3. Abbreviations

CO	Commissioning Oversight (functional)
INSO	Independent Nuclear Safety Oversight
NPP	Nuclear Power Plant or Project
SQUEP	Suitably Qualified and Experienced Person(s)

4. Oversight

This report has been developed to support nuclear operators in developing and implementing their own independent commissioning oversight function, which is a vital part of an effective safety management system for nuclear facilities. This report also identifies the role of independent oversight during commissioning to ensure functional and organisational readiness for start-up and long-term operation.

During commissioning and pre-startup phase, Commissioning Oversight and Independent Nuclear Safety Oversight should work closely with each other. Although differing in scope from each other, the two functions should act as complementary to each other to ensure oversight is provided to all facets of construction, commissioning and operational readiness. At the same time, from a defense in depth standpoint, it is beneficial for the Independent Nuclear Oversight to have oversight of the Commissioning Oversight. It is sometimes difficult for the rest of the NPP personnel to differentiate between Independent Oversight and Functional Oversight when the term used is “Oversight” so this needs to be taken into account by the INSO organisation.

5. INSO Program for Commissioning Oversight

Commissioning is the final step in the build process prior to operations and in many cases, the last opportunity to ensure the adequacy of critical design elements and the quality of construction. Dedicated oversight of commissioning provides valuable lessons learned going forward, significant learning opportunities for plant staff and provides assurance that the commissioning program demonstrates the plant has been constructed per design and as intended. It includes oversight of the commissioning program and strategy, management systems as well as the integrated checkout of all

systems, subsystems and components with performance testing with successful turnover, functional oversight program and quality.

Establishing a rigorous program of independent oversight, early in the build process, is a critical function for a successful project. Individual site arrangements such as contracts and organisational relationships will play a role in developing an oversight program suitable for the project however, the initial program structure and objectives should be established no later than project first concrete pour.

A good practice is to include scheduled and unplanned tasks/activities into the oversight programme based on risk analysis. The unplanned activities apply to both INSO and commissioning activities (i.e. non-quality critical rework needed for a welding task or equipment loading issue affecting the component's physical integrity). Oversight activities should also include manufacturer qualification testing (i.e. pressure test of heat exchanger).

6. Commissioning Oversight (Functional) Organisational Structure and Staffing

A proven functional organisational structure for the commissioning oversight (CO) team is one that is similar in alignment with the commissioning organisation. If the two programs (commissioning and oversight) are organisationally similar, effective communication and rapport are possible between CO and commissioning. Unlike traditional oversight roles, commissioning oversight is most beneficial when it is performed in close contact with the physical test activities themselves. Close relationships between CO and the commissioning staff are essential to a successful oversight program.

Qualification of commissioning oversight (functional) personnel should be approached differently than traditional oversight roles. Commissioning oversight is tactical in nature when compared to other oversight activities. Best practices would ensure the core CO staff are themselves experienced in NPP test activities including extensive experience in hands on commissioning. A qualification process that mimics the commissioning engineer qualification should be employed. This ensures the core CO organisation is populated with Suitably Qualified and Experienced People (SQEP) capable of providing the most impactful evaluation of and input to commissioning activities. The core group of SQEPs will also provide a solid base for learning opportunities for less experienced staff. This aspect of development is especially important for those countries that are new to nuclear.

7. Scope of Commissioning Oversight Program

The detailed scope of oversight activities may come from regulatory commitments, contractual requirements, design authority, lessons learned from previous efforts, QA program, etc., or a combination of these.

The scope of oversight should normally be the same whether the actual commissioning is performed by the client (owner), construction contractor or a third-party contractor. Also, the methodology employed can, with few exceptions, be scalable and applied to any reactor design or size.

Oversight activities for Commissioning element should ensure the availability of required commissioning resources, identification of critical interfaces & stakeholders, development of commissioning execution

plans, identification of terminal points & tie-in requirements, monitoring of owner/contractor commissioning and testing activities for successful turnover to an operational organisation.

8. Elements of Commissioning Program to be Overseen

The references cited in section 2 provide a comprehensive overview of commissioning programs developed for nuclear power projects. Individual elements of typical commissioning programs are identified in detail in these references. Each specific element is a potential subject for targeted oversight. However, given the scope of the commissioning program, the oversight organisation will need to focus on all aspects of safety (in the broad term: nuclear safety, radiological safety, industrial safety, environmental safety, quality, emergency arrangements/preparedness, security, etc.) and areas that have been problematic in previous commissioning efforts.

In order to do this more effectively, it is important for the Independent Nuclear Safety Oversight (INSO) function to allow a focus on the correct sequencing of commissioning activities as opposed to the project timeline/schedule, this should be done through a Commissioning Logic to help and assist the INSO function in targeting and identifying key commissioning activities.

The following are examples of subjects for targeted oversight. The issues described below do not constitute a complete oversight program but rather identify sample areas of concern from lessons learned and core subjects known to be critical to a successful commissioning program.

a) Commissioning organisation strategy and management systems

- i. Does the commissioning strategy include adequate emphasis and training of personnel on subjects important to safety and quality such as nuclear safety culture, use of human performance tools, quality of documentation, defense in depth and use of the corrective action program?
- ii. Does the commissioning strategy include appropriate training for personnel in specialized subjects such as identification of counterfeit and fraudulent items and equipment environmental qualification?
- iii. Is the management system identified and in place to support Commissioning. Is the commissioning staff sufficiently trained and qualified to use it effectively?

b) Commissioning organisation administrative program including administrative procedures

- i. They should be complete and well documented in approved procedures prior to the beginning of commissioning activities. Proposed future changes to the processes should include owner review for awareness.

c) Commissioning organisation staff qualification

- i. The commissioning organisation's qualification program should adhere to industry standards such as ASME NQA-1, IAEA NG-T-2.8 or other acceptable standards when providing suitably qualified and experienced persons. Experience level of the commissioning personnel should be provided by the contractor and evaluated regularly as personnel rotate over the life of the program.
- ii. Staffing should include a suitable number of positions reserved for less experienced individuals from the owner for training and knowledge transfer purposes. A best practice is to include this as a requirement in the contract for commissioning. Experience shows that

the contractor is not motivated to provide these training opportunities unless required to do so contractually.

d) Test procedure content and methodology

- i. Test procedure content, methodology and acceptance criteria should be approved by the design authority. This approval should be documented via a formal submittal and retention process.
- ii. If test procedure changes are required for any reason after issuance of the procedure, they should be well documented and subject to the same review rigor as the original procedure.
- iii. Best practice would include a line-by-line review including walkdown of sample test procedures associated with critical safety systems. This review should be performed by INSO personnel independently of CO personnel review.

e) Testing activities, overseen by actual test witness in the plant

- i. Physical attendance at selected test activities is crucial for any oversight program. Using a graded approach, test activities should be witnessed by oversight personnel. Procedure use and adherence and confirmation of test acceptance criteria satisfaction are necessary parts of oversight.
- ii. Results of the oversight should be documented and provided to both the organisation and the contractor leadership. Any gaps or adverse trends should be identified and mitigated as appropriate.
- iii. Ensure consistency of all tests performed from the supplier in the manufacture to the overall qualification on site (contractual testing, single or basic testing, functional testing, etc.) and where possible, with INSO personnel in attendance.

f) Completed test documentation review for accuracy, completeness and retention methods

- i. Oversight of completed test results is necessary to ensure that adequate documentation of test activities including results, deviations, changes and satisfaction of acceptance criteria are documented in an acceptable, retrievable fashion.
- ii. A graded approach to test result oversight may be applied but integrated system tests (pre-operational tests) should receive 100% review by the oversight staff. Detailed oversight of completed test results provides assurance that test requirements regarding scope and adequacy, have been satisfied.
- iii. INSO also needs to provide assurance on the process for accepting commissioning results by the representative of the operating organisation.
- iv. Substantiation of design basis studies versus content of operational technical specifications such as Limiting Conditions of Operation (LCOs) into electronic data systems in order to ensure consistency.
- v. Review of software versions to ensure configuration control for relevant programmable electronic devices (such as PLCs, etc.) and other I&C equipment.

g) System turnover from construction and installation to commissioning department and from commissioning department to the operational organisation

- i. System turnovers from the construction and installation to commissioning should include a list of incomplete (exception) items. These should be categorized by importance and scheduled for completion. The average number of exception items at the time of turnover should be evaluated as well as trended over time. The constructor's track record of resolving

the exception items should also be trended over time to identify adverse trends that could affect schedule and quality.

- ii. System turnovers from the commissioning department to the operational organisation should include significant oversight. This should include physical walkdowns, test result reviews and identification of incomplete items. System turnovers at this stage must include a detailed as-left equipment status report (valve, breaker etc. lineup) provided by the commissioning department prior to jurisdictional control change to the plant organisations. This equipment lineup/status should be approved by the plant organisations prior to accepting the system for turnover.
- iii. The turnover process also needs to take consideration of the interface between safety management of the constructor and the commissioning organisation. It is unlikely that commissioning will receive the whole plant and be able to reset management system arrangements. Therefore, the commissioning and construction organisations will have to have mutually compatible management system arrangements for control of work, industrial safety, etc. The INSO function should satisfy itself that the interface is sufficiently well defined and key processes are either common or have a well-defined interface capturing how, when and how long changes to arrangements are to be implemented for.
- iv. Maintenance documents and activities established for system turnover to maintenance. Operations document and activities (monitoring) for systems to turnover to operations. Ensure all as built documentation (drawing, plans, etc.) is available before handovers.

9. Graded Approach

Given the magnitude of the test program, it is necessary to use a graded approach to oversight. The graded approach process should be well documented in procedural format for consistency and transparency. The approach should consider as a minimum; safety significance of the system/equipment, risks associated with equipment failure, radiological concerns, personnel safety, economic risks from commissioning delays, etc. System/activity grading as a result of this evaluation should be used to establish areas of focus for oversight and where resource allocation will be most effective.

10. Periodic Program Evaluation

Periodic performance evaluations should include the oversight organisation as well as the commissioning contractor if appropriate based on contract requirements. Using standard processes of key performance indicators, trending reports, corrective action program review and regular assessments and/or inspections will identify gaps and areas for improvement. As highlighted in the main text of this guidance document, the oversight program should include standard processes for elevation and escalation where appropriate and a reporting line directly to a high-level executive.

11. Independent Nuclear Safety Oversight

The bases for INSO are the Operational Model the organisation has chosen or developed and the assurance of Nuclear Safety within the implementation of the Operational Model. An Operational Model helps defend against the forces that can erode operational and organisational margins. Rigorous execution coupled with constant organisational oversight, assessment, and reinforcement to defined operating standards and performance expectations provides a comprehensive and systematic defense against such forces. The more complete this level of defense is, the more effective and sustainable the operational model will be. A detailed and documented operating model whose components are integrated and complimentary and whose execution is constantly reinforced will sustain and grow operational performance and prohibit performance decline.

Using the WANO Pre-Startup Performance Objectives and Criteria Guideline (2013-2), certain performance objectives should be assigned to each Function to address, as well as certain relevant criteria. In addressing each performance objective, Function Owners must prove objectives have been addressed in their Function by either completing the suggested criteria or by demonstrating adherence in an alternative and comprehensive way. Fulfilling each criterion is not mandatory however compelling evidence must be provided to demonstrate that the performance objective has been met.

Operating Model

An Operational Model for New Nuclear Units normally addresses the following:

- Plant
- Programs
- Processes
- Procedures
- People

Plant

Plant refers to the readiness of the plant, systems, and equipment for safe, reliable and long-term operations. Assurance of readiness of the plant largely falls under the responsibility of Commissioning Oversight. This is where it is important for INSO and Commissioning Oversight to have the relationship where the right level of assurance is maintained; primarily, the Plant has been designed to effectively manage the Safety Margins associated with operating a nuclear power plant. Plant also includes software applications that are needed to support Function operations. Plant can be considered complete when all items have been procured and installed for use.

Programs

Programs are designed to tell the organisation what it does, who does it, when it is done, and why it is done. Programs are designed to exceed regulations and industry expectations. Programs are driven by requirements which are informed by regulations and standards. All programs should be assigned a Program Owner who is a technically qualified expert responsible for managing compliance. Programs can be marked complete when the following criteria has been met:

1. There is a technically qualified individual in place who has the knowledge to understand, explain, improve, measure and own the Program.

2. The Program Owner must also have completed any required training and/or education to ensure they are competent to meet the requirements of point 1.
3. Dependent and related Processes have been identified and their interfaces agreed between related Program and Process Owners.
4. Other related Programs have been identified and their interfaces agreed between related Program and Process Owners.
5. Supporting and implementing Procedures have been identified and completed.
6. All Plant items required to support the ongoing running and maintenance the Program are in place.

Processes

Processes are a structured set of activities designed to produce an output that is measured against specified criteria. They are designed to prevent errors and they support safe and reliable operations that undergo continuous evaluation to improve their actual effectiveness and efficiency. They reflect industry best practices and are the main drivers to achieving operational excellence.

Processes can be marked complete when the following criteria has been met:

1. There is a technically qualified individual in place who has the knowledge to understand, explain, improve, measure and own the Process.
2. The Process Owner must also have completed any required training and/or education to ensure they are competent to meet the requirements of point one.
3. Dependent and related Programs have been identified and their interfaces agreed between related Program and Process Owners.
4. Other related Processes have been identified and their interfaces agreed between related Program and Process Owners.
5. Supporting and implementing Procedures have been identified and completed.
6. All Plant items required to support the ongoing running and maintenance the Program are in place.

Procedures

Procedures are used to implement the organisation's programs, processes and other work activities. By using procedures, it is ensured that a high level of error-free performance is achieved. By using procedures, the organisation proactively reduces human error and ensures event-free operations. Procedures can be considered complete when they have been developed reviewed and approved through the applicable approval document process based upon internal and regulatory requirements.

People

People reflects all employees who work for the organisation. They are technically trained and fully understand the goals, mission and vision of the organisation. It is important that the people, especially those new to the nuclear industry understand what it means to be a Nuclear Professional and respect Nuclear Safety Culture. People can be considered complete when all staff matching the approved organisational charts have been hired, on-boarded, trained, and qualified for position.

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