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SUB-CHAPTER 19.1 – PLANT COMMISSIONING PROGRAMME

1. METHOD FOR DEFINING COMMISSIONING TESTS

1.1. OVERVIEW AND OBJECTIVES OF THE METHOD

Commissioning tests serve as a progressive transition between the erection, installation and the start of normal operation of the various plant systems. These tests may take place in-factory, on specific test facilities or on-site. The choice depends on the type of equipment, on the level of a system's integration that can be simulated off-site (e.g. I&C systems), and on the ability to obtain specific conditions on-site (e.g. for qualification tests or accident transients).

The method for defining commissioning tests is chosen with the following objectives:

- To ensure that all operational aspects of system functions are tested, including safety-classified functions, taking into account off-site tests, where relevant.
- To serve as the basis for designing commissioning test documentation.

1.2. PRINCIPLES OF THE METHOD

Since the main purpose of commissioning tests is to ensure that plant systems will perform according to their design intent (as defined in the safety case), the analysis is based on reference documents that define and describe the system-related functional aspects and specifications. This reference material is mostly obtained from plant system manuals and from specifications in plant equipment lists.

2. SCOPE OF THE PLANT COMMISSIONING PROGRAMME

The plant commissioning phase ranges from erection to commercial operation. It is organised into two test categories:

- Pre-operational tests and
- Initial start-up tests (operational tests).

Plant commissioning tests cover all operations performed on equipment, systems and structures – notably those that are safety-classified – in order to ensure that they behave as specified in the design requirements.

The following description gives a preliminary overview of the plant commissioning programme. Only the main tests phases are listed, mainly for information. The detailed and comprehensive programme will be made available during the detailed design phase as a result of the identification method (see section 1 of this sub-chapter) and before the first tests are run on the plant.

The plant commissioning programme (see Sub-chapter 19.1 - Figure 1) is carried out in three main phases:

Pre-operational test programme:

- *Phase I*: includes the preliminary tests and controls, the first start-up of equipment, functions or group of functions, without any interaction between the reactor coolant system (or its auxiliary systems) and the secondary-side systems;
- *Phase II*: includes cold and hot functional tests of the reactor coolant and secondary-side systems before fuel loading.

Initial start-up test programme:

- *Phase III*: includes core loading, cold and hot pre-critical tests and actual start-up, including a “Demonstration Run”, up to “Commercial Operation Date”.

Start-up tests include:

- *Standard start-up tests*, which are designed to verify the proper operation of the installation and its compliance with the associated performance objectives;
- *Tests, which are repeated at different power levels* during power escalation (core physics and control systems tests) for the purpose of confirming, for each power level, the validity of the hypotheses used by the plant operation and safety analyses and during the protection system design;
- *Operating procedure validation tests*: normal operating procedures are widely used during the start-up test and are thus validated by such tests. Incident and accident procedures are validated whenever possible during the plant commissioning. All of them are in any case validated on a simulator by using adapted computer codes;
- *“First-of-a-kind” tests* are performed in order to verify an innovative concept, which has not yet been validated. Such tests may require specific instrumentation capable of confirming theoretical data.

The tests described below concern safety-classified systems and equipment.

3. PRE-OPERATIONAL TESTS

The pre-operational test programme includes all the checks, controls, fine-tuning, set-up and functional tests that are required to guarantee that the first core loading, the first criticality and the low-power tests can be performed without impairing safety.

The tests are organised by sequences so that the satisfactory completion of one test ensures the safe performance of subsequent tests. Steps could therefore necessitate the simulation of some operating situations that cannot otherwise be achieved at this stage. As soon as this situation can be obtained in real condition, the corresponding tests are repeated in the subsequent step.

Chronologically, the tests are first conducted without fluid or by simulating various signals, then by bringing more and more complete functional assemblies into operation, thereby replicating as far as possible normal operating conditions.

Where necessary, abnormal operating conditions can be simulated, insofar as they do not jeopardise personnel security, equipment integrity or the cleanness of the various systems.

Pre-operational testing begins after completion of the erection phase.

Demonstration that equipment and functional assemblies operate correctly, as well as the corrective measures to be taken in case of non-conformances, are based on analysis of the test results.

All pre-operational tests are normally completed before the initial core is loaded. This is not the case for tests performed on equipment or functional assemblies that can only be operated after core loading. An example is the case of control rod system tests. Complete hot and cold tests are performed on this equipment after core loading and before actual reactor start-up.

Moreover, when a pre-operational test cannot normally be completed before initial core loading, due to unavailability of associated equipment and/or systems or when its results are deemed unsatisfactory, then the test may exceptionally be carried out or repeated after loading has taken place. However, neither test performance nor lack of test results may in any way conflict with the safety requirements.

Pre-operational tests are conducted using specific test procedures as well as operating procedures that can be adapted, where necessary, to testing.

Pre-operational tests are performed in two phases:

- Phase I: preliminary tests
- Phase II: plant functional tests (before fuel loading)

Phase II is further broken down into four sub-phases:

- Cold functional tests (phase II-1);
- Preparation of hot functional tests (phase II-2);
- Hot functional tests (phase II-3);
- Preparation for fuel loading (phase II-4).

4. INITIAL START-UP TEST PROGRAMME

Operational tests are carried out under actual operating conditions. The operational test programme is designed to meet the following major objectives:

1) Demonstrate that the plant unit operates in accordance with design bases, specifically with regard to safety requirements. This demonstration primarily implies verifying:

   - That the unit operates correctly under steady state and transient conditions,

- That plant performance complies with safety criteria,
- That hypotheses postulated for safety analysis are suitably conservative,
- That operating rules are suitably adapted to the plant.

2) Show that the plant is capable of generating the power required under the specified operating conditions,

3) Provide measured data for use as a reference in subsequent plant operation during plant-life.

Operational tests correspond to phase III, which include, pre-critical tests, criticality and power escalation. This phase is broken down into four sub-phases:

- Initial core loading (sub-phase III-1),
- Pre-critical tests (sub-phase III-2),
- Initial criticality and escalation to 50% full power (sub-phase III-3),
- Escalation to full power (sub-phase III-4).

SUB-CHAPTER 19.1 - FIGURE 1: PLANT COMMISSIONING PROGRAMME (PRINCIPLES)