OPAL Reactor Commissioning and Operations Planning

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ABSTRACT

ANSTO's new reactor facility, OPAL, is a multipurpose 20 MW open pool reactor fuelled by 16 low enriched uranium fuel assemblies. INVAP S.E., Argentina, and its Australian subcontractors are responsible for the design, construction and commissioning of the OPAL reactor. Concrete pouring commenced in November 2002 and Commissioning is scheduled to commence in late 2005.

In order to support the commissioning process, a systematic inspection and testing program has been implemented to demonstrate the performance of all systems, particularly those with a safety function. Therefore, tests of the systems and components of the OPAL reactor are rigorously performed during the installation, pre-commissioning and commissioning stages. Testing is planned and organised in a logical sequence aimed to demonstrate individual system performance and subsequent integration with other plant systems. In particular, the Commissioning Stages involve a comprehensive series of system integration, fuel loading, power ascension and full power tests, in full accordance with IAEA recommendations. These tests are performed with the application of Commissioning Procedures as issued by INVAP and reviewed by ANSTO in order to ensure completeness and suitability.

A Commissioning Plan defines and states the framework for all of the Commissioning activities and four specific plans (named as Stage A/B1/B2/C Specific Commissioning Plan) detail the individual stage.

This paper provides a summary of the contents of these Plans and an overview of the operational arrangements that will be implemented in order to ensure safe and efficient commissioning of the OPAL Reactor as well as the further transition to Routine Operation arrangements.

INTRODUCTION

The OPAL Reactor project has been organised in the following project phases:

1. Launching phase
2. Preliminary Engineering phase
3. Detailed Engineering phase
4. Construction phase
5. Manufacturing and Procurement phase
6. Installation phase
7. Pre-Commissioning phase
8. Commissioning phase
    a. Cold Commissioning (Stage A Commissioning)
    b. Hot Commissioning (Stages B1, B2 & C Commissioning)
9. Contract Performance Demonstration Test phase

The Engineering phases consisted of the design of structures, systems and components and the preparation of design documentation, including drawings, specifications, calculations and analyses. This was followed by the construction, manufacturing and installation phases where activities were performed and controlled in accordance with the project construction Inspection Test Plan together with individual Specific Inspection and Test Plans.

Activities from the Construction phase up to and including the Cold Commissioning phase are performed under a Construction Authorisation issued by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA). An application for an Operating Licence has been made to ARPANSA and the issuance of the Operating Licence is one of the prerequisites for fuel loading and Hot Commissioning.

Prior to the commencement of the Pre-Commissioning Phase, ANSTO created an Organisational Structure to support OPAL Commissioning and Operations. This involved the selection of individuals to become part of the OPAL Commissioning Operations Group and undertake a comprehensive design and operations theory training course. Individuals have been selected to undertake further specific training to become Reactor Operators and/or Shift Managers. Commissioning teams have actively participated in many post installation and pre-commissioning tests in order to gain hands on experience with plant and equipment. An OPAL Business Management Quality System has been implemented and all necessary operating documentation is in the process of being drafted and issued in preparation for Hot Commissioning.

Hot Commissioning is due to commence in the first half of 2006. The Operating and Commissioning organisation, staffing and documentation arrangements are being put in place for the commencement of commissioning and smooth transition to routine operation.

COMMISSIONING PREPARATIONS

Testing Prior to Commissioning

Numerous inspections and tests are performed on each OPAL reactor system during construction and pre-commissioning in order to support the Commissioning phases and assist in facilitating the regulatory approval process. Such inspections and tests are intended to demonstrate the performance and safety functions (where applicable) of OPAL plant and equipment. These inspections and tests include factory acceptance tests, site reception tests, installation tests, functional tests and pre-commissioning tests.

Pre-commissioning tests are performed to demonstrate the following:

- The plant systems and subsystems operate as expected and in accordance with their design objective;
- The plant meets occupational health and safety requirements and other statutory requirements;
- The plant interfaces appropriately with other systems, subsystems, equipment or services;
- The documentation is appropriate for operations and maintenance activities.

Documentation

INVAP is responsible for the preparation of operational documentation and the drafting of the Safety Analysis Report. ANSTO have reviewed draft documentation and provided comment to INVAP through a formal review process. The Safety Analysis Report was issued to ARPANSA in August 2004 as part of ANSTO's application for an operating licence. Other operating documentation such as Design Manuals, Operations Manuals and Maintenance Manuals are in the process of being reviewed by ANSTO and progressively finalised and issued by INVAP. This operating documentation will form part of the OPAL Business Quality Management System which has recently gained AS/NSZ ISO 9001:2000 quality certification.

All precommissioning and commissioning tests are planned, conducted and controlled using detailed approved procedures prepared for each individual test. INVAP are responsible for the preparation of such procedures and ANSTO have the opportunity to review and make comment on each procedure. Procedures are prepared to demonstrate compliance with selected acceptance criteria. Detailed records are kept during each test and reports are prepared by the commissioning team.

Staffing

ANSTO has created an OPAL Commissioning Operating Organisation and selected staff were chosen by an internal and external recruitment process. At present there are approximately 50 individuals within the OPAL Commissioning and Operating Organisation, this includes management, engineers, scientist, reactor operators and administration support. A comprehensive five month training program on OPAL reactor design and operations was attended by approximately 30 staff members and

selected individuals will undertake further specific operations training, simulator training and practical plant training in order to become authorised reactor operators and shift managers. Throughout the commissioning phase, additional staff will be acquired from the OPAL Project team and from within the existing HIFAR Operating Organisation to facilitate the ongoing operation of OPAL.

COMMISSIONING PLANNING

Commissioning Stages

OPAL commissioning is organised into four stages, these are:

- Stage A - pre fuel loading tests
- Stage B - fuel loading and approach to criticality
- Stage C - power ascension and power tests
- Contract Performance Demonstration Tests

Stage A tests consist of complete system integration tests following precommissioning testing. This is done prior to the loading of fuel to demonstrate the capability of systems and to provide assurance that the plant is ready for fuel loading.

Stage B commissioning commences with the progressive loading of fuel into the core and taking the reactor critical for the first time. This is then followed by a series of low power tests aimed at demonstrating shutdown systems and the measurement of neutronic parameters.

Stage C consists of progressively increasing reactor power up to 100% of full power. This is done whilst performing thermal balance tests and the correlation of thermal power with nucleonic instrumentation and verifying the effectiveness of biological shielding. Following Stage C commissioning the plant is considered to be fully operational.

Contract Performance Demonstration Tests are undertaken to confirm compliance with contract performance acceptance criteria. This involves the measurement of a series of parameters such as neutron flux distribution and spectra within irradiation facilities and neutron guides.

Commissioning Plan

The commissioning plan describes the objectives of commissioning and the general activities to be performed throughout the commissioning phase. The commissioning organisational structure has been developed with each of the following groups having a clear function and responsibility:

- Management group
- Commissioning group
- Commissioning teams
- Construction group
- Operations group
- Commissioning Safety Review Committee
- Commissioning Quality Assurance group

Commissioning plans and activities are performed in accordance with IAEA recommendations. All commissioning tests are performed with detailed written and approved procedures. The results of commissioning tests are recorded and then used to compile a final report for each commissioning stage or substage. The commissioning reports will include a summary of the tests performed, limitations, deficiencies and resolutions, analyses, conclusions and recommendations.

Verification of commissioning test results will be preformed by the commissioning team to confirm that the test was performed as stated in the procedure and that relevant parameters associated to the acceptance criteria have been obtained. The review of commissioning activities will be carried out by the Management group based on the commissioning reports.

Stage Specific Commissioning Plans

Stage specific commissioning plans describe in detail the particular activities being performed during each stage of commissioning.

Stage A commissioning tests are performed to demonstrate that plant systems properly function in an integrated manner before proceeding to stage B1 and loading fuel into the core. Much of the stage A commissioning tests involve functionality testing of the instrumentation and control systems (for example first and second reactor protection systems, post accident monitoring system and the reactor control and monitoring system). Other tests performed during Stage A commissioning include:

- Reactor state tests (shutdown state, power state, refuelling state, physics test state)
- Emergency preparedness test
- Containment and containment ventilation systems tests
- Control rooms tests
- Entire facility cold run test
- Cold neutron source and Neutron beam facilities tests

During Stage B1 commissioning, fuel assemblies are progressively loaded into the core for the first time and the reactor is taken critical. Activities and tests performed during stage B1 include:

- Setup of safety systems
- First reactor core fuel load
- Approach to criticality
- First shutdown system shutdown margin measurement

Stage B2 commissioning involves the continuation of fuel loading followed by a series of low power tests to demonstrate that the reactor core complies with the nuclear and thermal-hydraulic design and the verification of the adequacy of control and shutdown systems. Test performed during commissioning stage B2 include:

- First and second shutdown systems shutdown margin measurements
- Control rod calibration and excess reactivity measurement
- Power calibration of nuclear instrumentation
- First and second shutdown systems actuation tests

- Neutron flux distribution and power peaking factor measurement
- Reactivity coefficient measurements
- Kinetic parameters evaluation
- Irradiation facilities reactivity worth measurement
- Reactor shielding and area radiation measurements

Stage C commissioning comprises tests during reactor power ascension and final tests at full power in order to demonstrate that the rector can be operated in a safe manner. Reactor power will be increased in steps and a series of tests will be performed at each power step to confirm that further power increases can continue in a safe manner. Test performed during commissioning stage C include:

- Reactor measurement tests
- Health physics measurements and shielding tests
- Cold neutron source tests
- Irradiation facilities tests

Commissioning Procedures

Commissioning tests and activities will be performed in accordance with detailed written procedures. All individual procedures provide an objective, method, equipment requirements, data sheets and acceptance criteria. Commissioning procedures will be managed by the Commissioning group in accordance with the Commissioning Quality Assurance Plan

DISCUSSION

A systematic inspection and testing program has been implemented to demonstrate the performance of OPAL reactor systems, particularly those with a safety function. Commissioning activities will be performed in accordance with IAEA regulations, the Commissioning Plan and tests will be performed using approved procedures and instructions. The Commissioning Operations Organisational has been created and staff have undergone detailed design and operations theory training. Arrangements are being put into place to facilitate the safe and efficient commissioning of the OPAL reactor followed by a smooth transition to routine operation.