Australian Government

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Nuclear-based science benefiting all Australians

IGORR 12, Beijing

OPAL Commissioning and Early Operation – a Shift Manager's Perspective

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Overview

- Introduction
- OPAL Project – Early Days
- Transition from HIFAR to OPAL
- Commissioning
- Problems during initial operation
- Conclusion

General View of ANSTO Campus

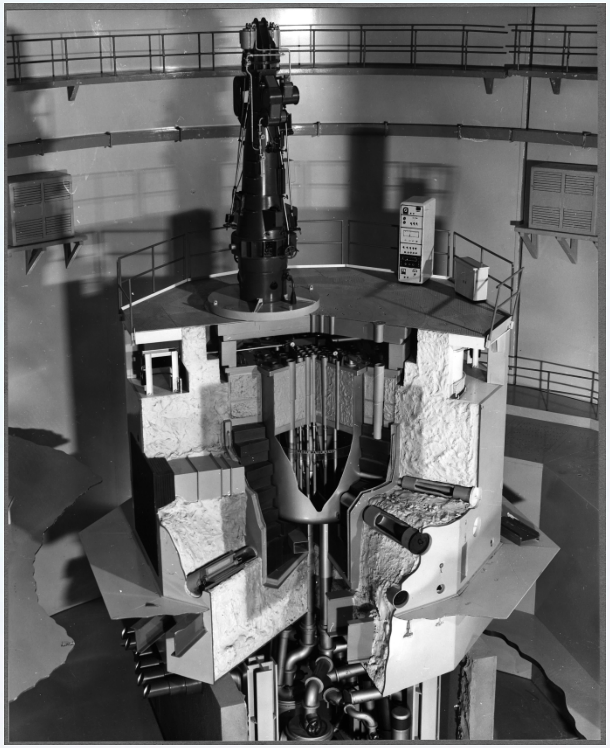
Introduction

HIFAR

OPAL

HIFAR

- 10 MW DIDO type reactor.
- Heavy water in a closed tank.
- Heavy water acts as the primary coolant and also as the moderator.
- 1st criticality in January 1958.
- Closed down on its fiftieth year of operation in January 2007.

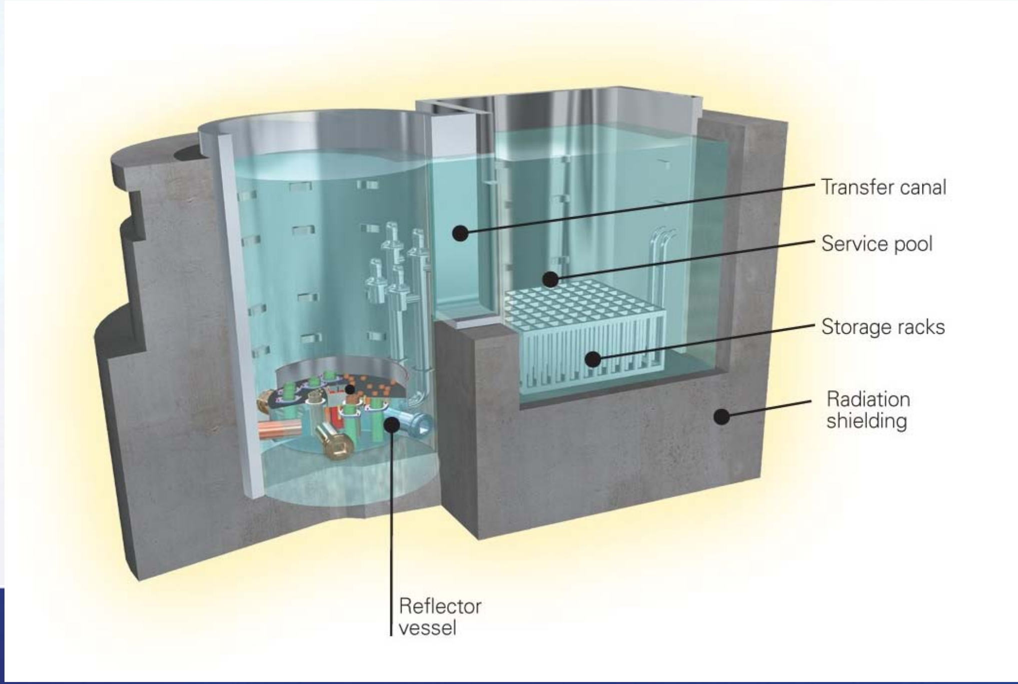


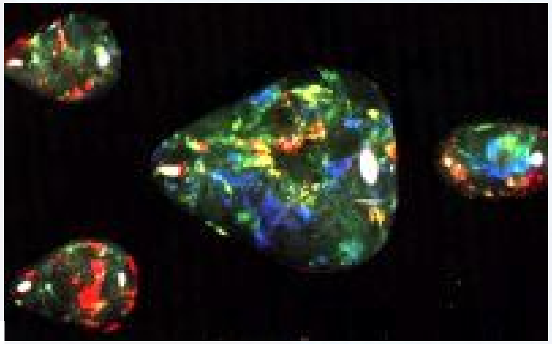
Cross-section of HIFAR

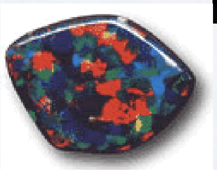
The former Minister for Education, Science and Training pressing the button to shut down HIFAR

OPAL - Open Pool Australian Light-water Reactor

- OPAL is a multi purpose reactor with a thermal power of 20 MW.
- OPAL achieved first criticality on 12 August 2006.



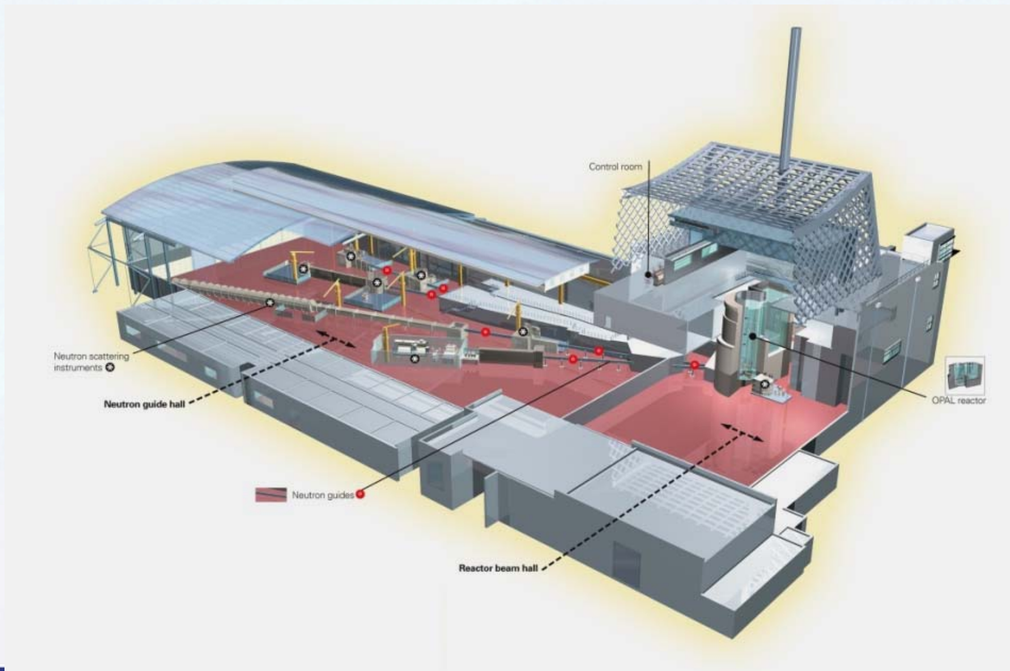




Opal is one of the world's most beautiful and precious gemstones. It is one of only six types of precious gemstones found on planet earth, sharing prestigious company with diamonds, rubies, sapphires, emeralds, and pearls. Over 95% of the world's precious opal comes from Australia.

OPAL PROJECT – EARLY DAYS

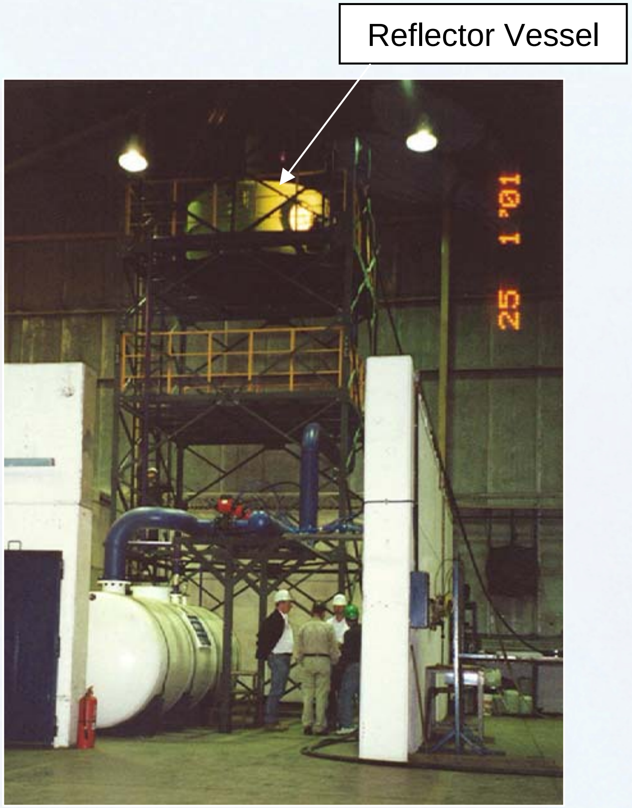
Successful tenderer
- INVAP of Argentina.



ANSTO and INVAP – common goal is to design and operate a modern, state-of-the-art multi-purpose reactor.

OPAL PROJECT – EARLY DAYS

- Training in INVAP headquarters working with INVAP engineers.
- Better understanding of the design concept;
- at the same time I was able to develop friendship and goodwill with the INVAP personnel.



Mock-up of the Second Shutdown System, INVAP Workshop, Bariloche, Argentina.

Socialising with INVAP staff.

TRANSITION FROM HIFAR TO OPAL

- Experience
- OPAL training and accreditation
- Safety culture
- Business Management System (BMS)

Sydney Harbour Bridge

Experience

Working on HIFAR Top Plate

- HIFAR - nearly fifty years of safe operation.
- Developed a pool of very experienced reactor operators; including engineering, maintenance, operational and other support staff.
- Transfer the expertise from HIFAR to OPAL.

Experience (cont.)

Kangaroos under the shade of a gum tree.

Dual operation - HIFAR and OPAL

- maintain sufficient number of staff to continue operating HIFAR safely.
- release some of these staff from HIFAR for training in OPAL.
- different systems in HIFAR and OPAL in terms of design and technology.

Experience (cont.)

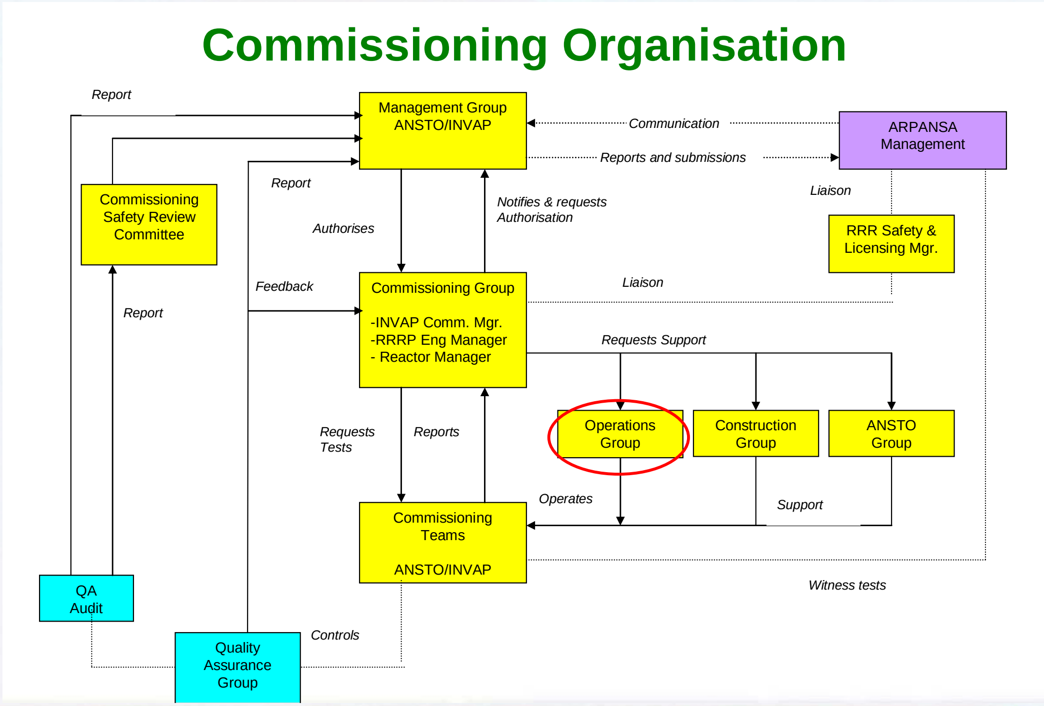
HIFAR Control Room

OPAL Control Room
– looking out to the Reactor Hall

Experience (cont.)

OPAL Commissioning Operating Organisation

- to manage the recruitment of operations staff.
- training of operations staff.
- manage the operational aspects of commissioning.



Experience (cont.)

The Operations Group is made up of:

- HIFAR staff, engineers and scientists from various divisions in ANSTO – Safety, ANSTO Health and Environment.

The Neutron Guide Hall

Experience (cont.)

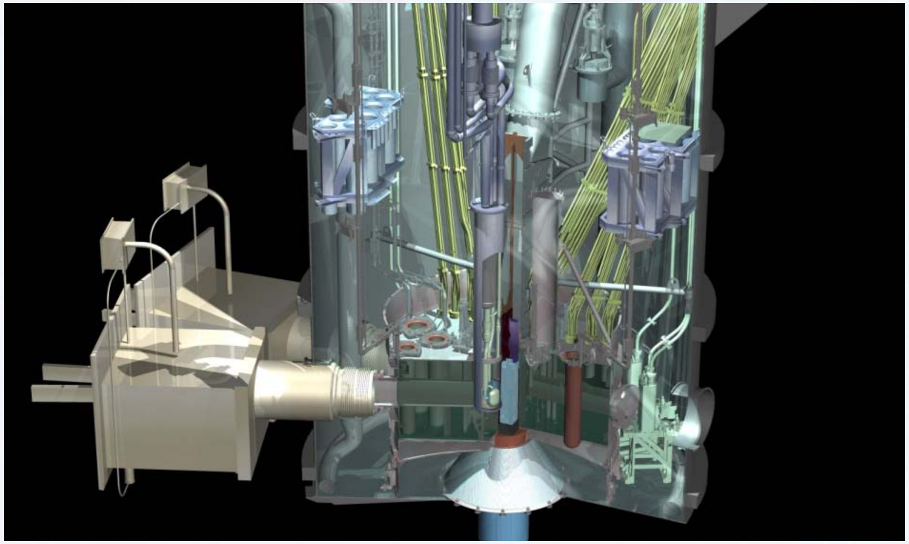
The Operations Group also included

- A batch of nine recently graduated engineers and scientists recruited in early 2003 with the intention for them to work in the new reactor project.
  - » training in HIFAR - in operations, engineering and maintenance.
  - » involved in OPAL documentation review.
  - » training in INVAP headquarters in Argentina.
  - » OPAL commissioning in 2006 - more than three years of nuclear experience.

Lago Nahuel Huapi, Bariloche, Argentina

OPAL Training and Accreditation

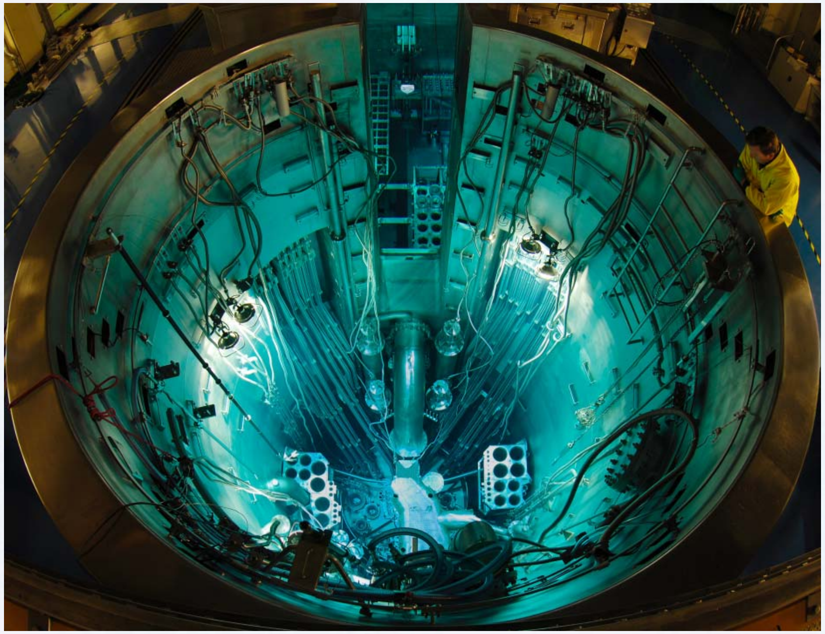
- 30 staff members underwent training
- Trainees from HIFAR and OPAL and included:
  - Managers
  - Engineers
  - Maintainers
  - Nuclear Physicists
  - Health Physicists
  - HIFAR operators
- Staff seconded from within ANSTO.
- New recruitment.
- Contractors.



Cross-section of the Reactor Pool

OPAL Training and Accreditation (cont.)

- Training course:
  - 5-month comprehensive training program
  - Simulator
- Involvement in pre-commissioning activities.

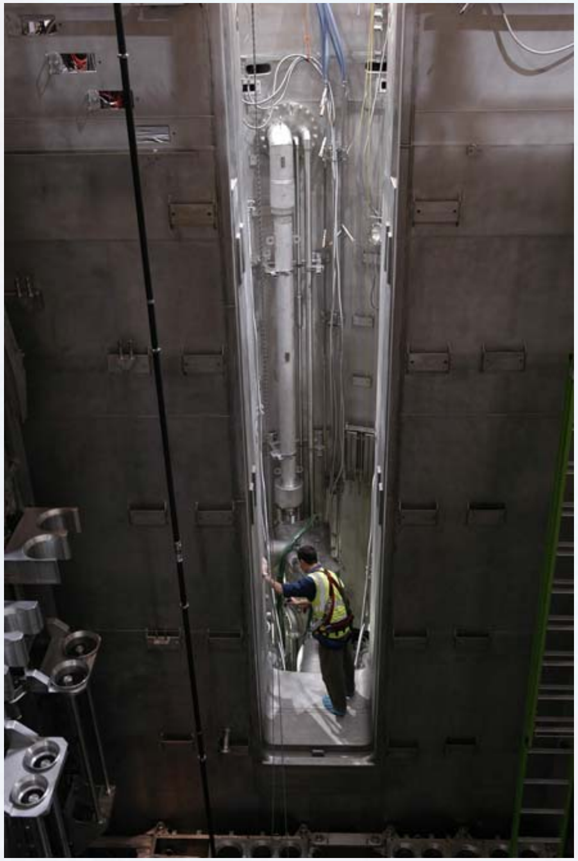


Looking down the Reactor Pool

OPAL Training and Accreditation (cont.)

- Pre-commissioning activities

Group	System
0	General Information
1A	Reactor Systems
1B	Reactor Process Systems
2	Plant Systems
3	Buildings and Structures
4	Instrumentation and Control
5	Services and Utilities
6A	Neutron Facilities
6B	Irradiation Facilities
7	Documentation



The Transfer Canal – looking from the Service Pool to the Reactor Pool

OPAL Training and Accreditation (cont.)

- The operations team members helped in the tests to verify and validate plant performance.
- Further interactions between the INVAP and Operations staff.
- Improved previously established good relationship with the INVAP personnel.
- Intimate involvement with the plant and equipment reinforced the understanding of the reactor systems.

Social interaction – ANSTO/INVAP staff

OPAL Training and Accreditation (cont.)

At the end of the training,

- Eight were accredited as Shift Managers.
- Many have years of experience in the Nuclear industry, either in HIFAR or in other roles - in nuclear safety or radioisotope production.
- One became the Operations Manager.
- The Shift Managers and accredited Reactor Operators formed the shift crews.
- Final make-up of the shift personnel was a balance of experience and early career enthusiasm.

View of the Control Room and the Reactor Hall from Shift Manager’s desk

OPAL Training and Accreditation (cont.)

- Plant Operators – take care of the external plant and under the instruction of the Reactor Operator.
- They were selected by an internal and external recruitment process.
- Successful candidates were authorised to perform duties as Plant Operators.
- Additional training given to Plant Operators for them to be successfully accredited as Reactor Operators.

Boab Trees, found in Australian desert, store water in their trunk giving them the bottle shape

OPAL Training and Accreditation (cont.)

Koala resting on a tree branch

- At present all but one Plant Operators are accredited Reactor Operators.
- The Plant Operator is a transitional position and the intention is to have all on shift to be accredited as Reactor Operators.
- The Reactor Operators alternately perform the role as Plant Operators.
- The interchange-ability of these two positions:
  - provides flexibility in personnel management,
  - enhances safety of reactor operation with their hands-on involvement with the plant.

Safety Culture

- Establish a culture where team members will contribute to a work environment that is:
  - safe,
  - professionally challenging and positive,
  - promotes teamwork in a manner that is cooperative and respectful.
- Assimilate the good practices of HIFAR.
- Further enhance the emphasis on safety.

Safety Culture (cont.)

- Stop-Think-Act-Review - the STAR principle is strongly encouraged in carrying out the everyday activities.
- Tasks are performed in strict adherence to approved procedures.
- The *Business Management System* helps towards achieving this objective.
- Current practices contribute to enhancing the safety culture in OPAL.

STAR
Stop-Think-Act-Review

Business Management System (BMS)

- BMS assists with safe operation of OPAL.
- It forms the framework for the implementation of quality principles to achieve ANSTO objectives.
- In mid 1990s HIFAR obtained ISO 9001 accreditation.
- The remaining group of staff that developed the HIFAR QA system was available and became the core team members in developing the OPAL BMS.

Unique Australian animal - a platypus

Business Management System (BMS)

- OPAL attained ISO 9001:2000 and ISO 14001:2004 accreditations prior to commissioning.
- Has the unique achievement of obtaining the accreditations without an operating plant.
- The BMS became the framework under which the OPAL organisation operated during commissioning.
- Currently OPAL operates under a much more developed form of the BMS.

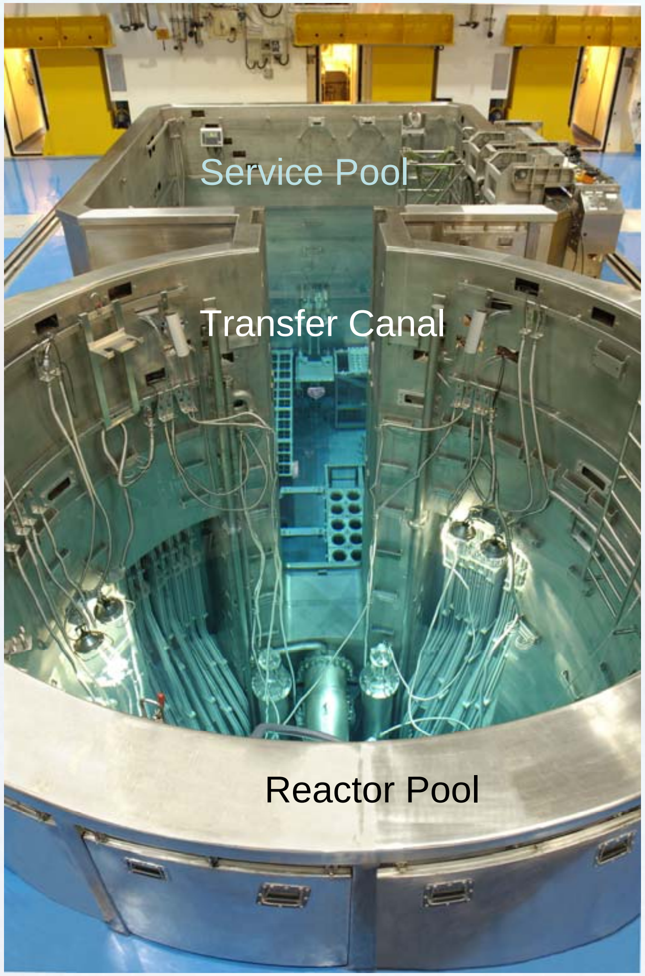
COMMISSIONING

- OPAL commissioning was organised into four stages, these were:
  - » 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.

The Sydney Opera House and the Botanic Gardens

Stage A Commissioning

- Stage A tests consist of complete system integration tests following pre-commissioning tests.
- During this time, the trainees assisted in carrying out the tests to improve their plant knowledge.



Stage B Commissioning

- Stage B1 Commissioning
  - the progressive loading of the fuel into the core.
  - First critical 12 August 2006 with 14 fuel assemblies loaded.
  - First Shutdown System shutdown value measured.
- By this time, training and appointment of the Shift Managers and Reactor Operators had been completed and the shift crew were manning the reactor full time.

Stage B Commissioning (cont.)

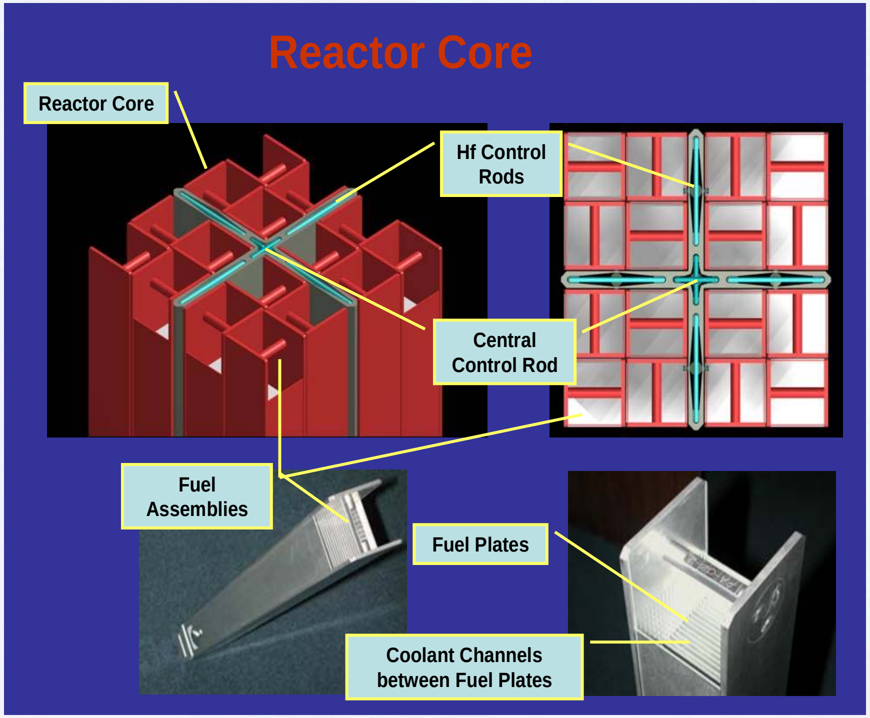
- The authority and responsibilities were clearly defined.
- The established protocol was that only the accredited Shift Managers and Reactor Operators:
  - have the authority to operate the reactor
  - they have the full responsibility for the safety of the reactor.
- All commissioning activities were undertaken with the approval of the Shift Manager on duty.

During Reactor commissioning

Stage B Commissioning (cont.)

Stage B2 Commissioning

- Completed loading of full core – 16 fuel assemblies.
- 22 main tests at powers up to 400kW.
- Irradiation of gold wires for determination of:
  - power peaking factor.
  - reactivity worth of facilities .
  - calibration of nuclear instrumentation.
- All feedback coefficients confirmed negative.

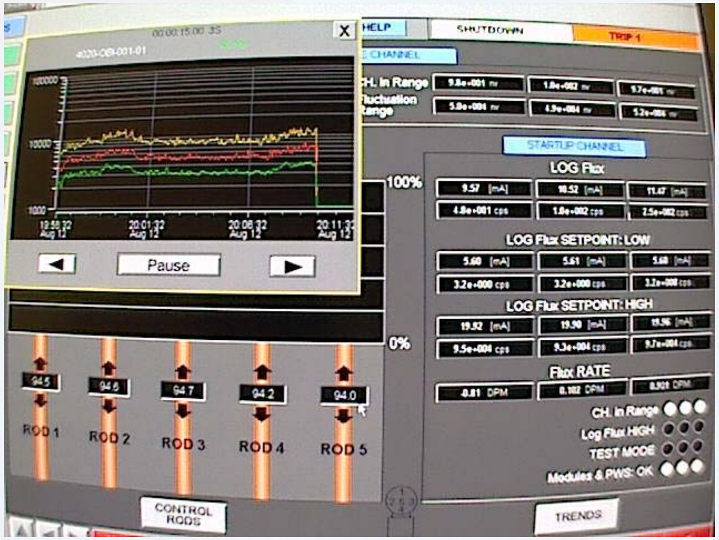


Stage C Commissioning

- A series of low power tests aimed at demonstrating:
  - the functionality of the shutdown systems.
  - the measurement of neutronic parameters including control rod calibrations.
- Reactor power increased in steps to 20 MW.
- Nucleonic instrumentation calibration at 3 MW from thermal balance.
- Loss of normal electrical supply test from full load.
- 20 MW achieved 03 November 2006.

Stage C Commissioning (cont.)

- Intense learning period for the operation staff.
- Multiple start-ups and shutdowns of the reactor equivalent to condensing many reactor operating cycles into a very short period.
- Providing opportunities operations staff to experience the various behaviours of the reactor systems under controlled conditions.
- Able to ‘feel’ the response of the reactor control system with respect to Control Rod movements during their calibration.



PROBLEMS DURING INITIAL OPERATION

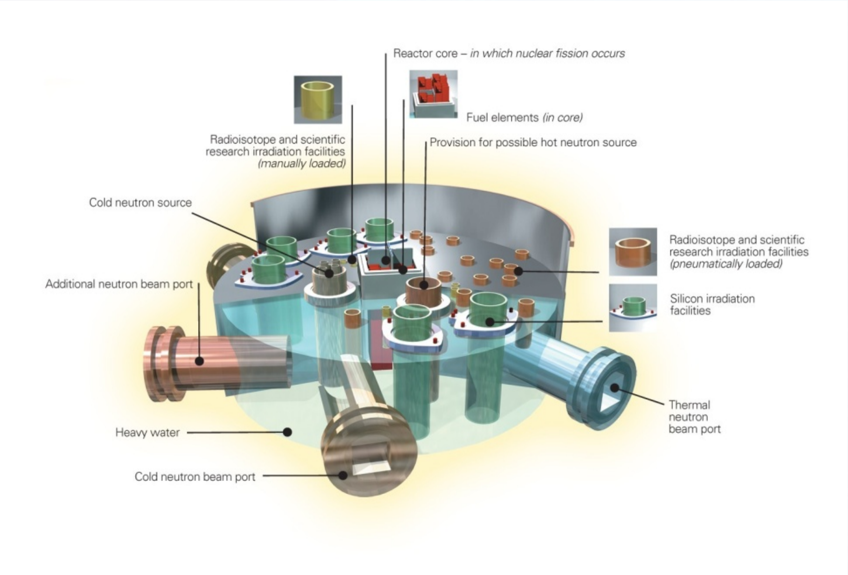
- Leak in Reflector Vessel
- Fault in Fuel Assembly

Reflector Vessel – during installation

A Fuel Assembly

Leak in Reflector Vessel

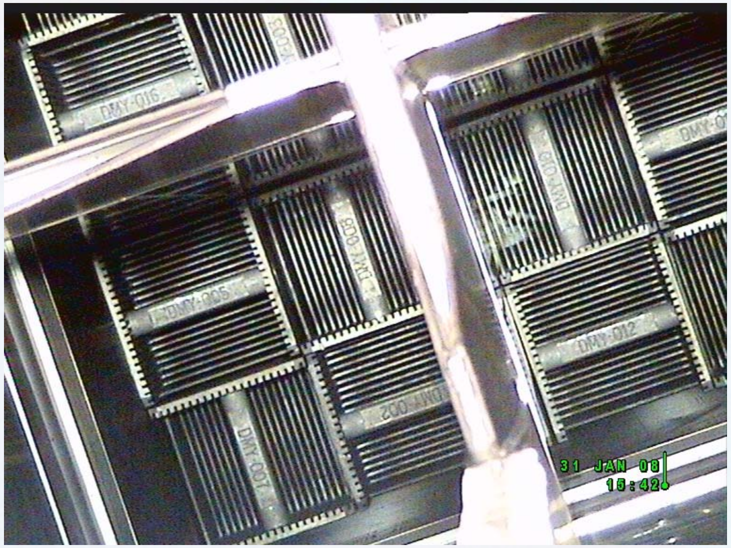
- The purity of the heavy water in the Reflector Vessel decreased from 99.93% to 99.48% on 11/01/07 after about 6 months operation.
- The leaks were traced to weld defects in different positions on the flanges of three beam tubes on the Reflector Vessel.



Cutaway view of the Reflector Vessel

Fault in Fuel Assembly

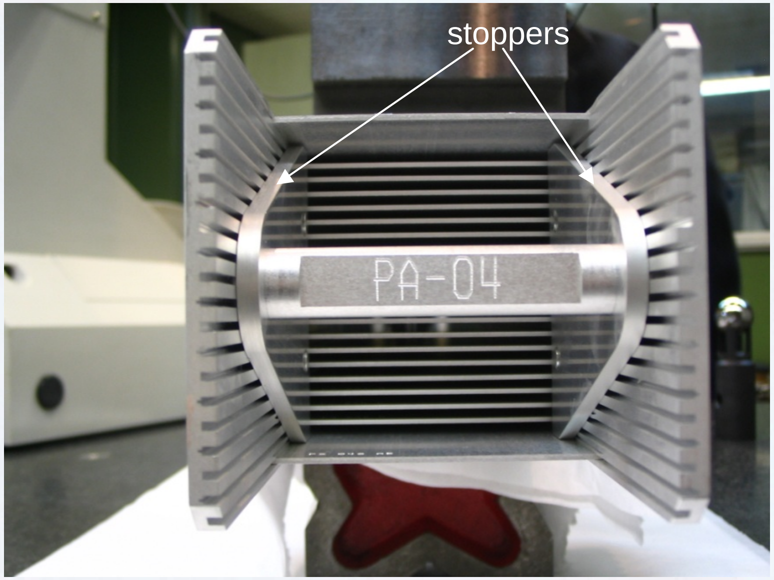
- Caused the reactor to be shut down for a period of about 10 months.
- First observed during a core video inspection following refuelling in July 2007.
- Several fuel plates were noticed to have been vertically displaced from their normal positions in several fuel assemblies.
- Investigation revealed problems with the fuel design (no secondary stopper), and other contributing factors.



Arrangement of Fuel Assemblies in the Core

Fault in Fuel Assembly (cont.)

- The design was modified to include a stopper to limit longitudinal movement of the fuel plates .
- The stoppers provide a defence-in-depth feature that prevents significant fuel plate displacement.
- A new start up core was manufactured for the return to service of the reactor.
- In May 2008, the Regulator approved the return to service program.



Fuel Assembly with stoppers

Reactor operation during this period

- During fuel fault investigation and modification of the fuel assemblies, opportunity was taken to repair the leak in the Reflector Vessel.
- Remedial solutions taken so far were successful to reduce the rate of light water ingress into the Reflector Vessel.
- The operation of the reactor has not been significantly affected by this defect.
- There is now a committee tasked with finding an engineering solution for a permanent fix to the problem.

Aboriginal art

Reactor operation during this period (cont.)

During the 10-month shutdown period, the Operations staff

- Helped in the investigative tests
- Performed operational tasks during the repair of the Reflector Vessel.
- Continued to operate the reactor in the shutdown state
  - Maintained the unaffected systems such that the systems were fully functional.
  - All OLC requirements of the reactor were strictly complied with;
  - All OLC surveillance requirements were performed as applicable to an operating reactor.

Woronora River, near ANSTO

Reactor operation during this period (cont.)

- The return to service strategy was to demonstrate the operational readiness of the plant.
- Incorporated tests necessary to load the start-up fresh fuel, achieve criticality and raise power incrementally to 20 MW.
- The testing was based on the original reactor Stages B and C Commissioning.

The Twelve Apostles, Great Ocean Road, Victoria, Australia

Reactor operation during this period (cont.)

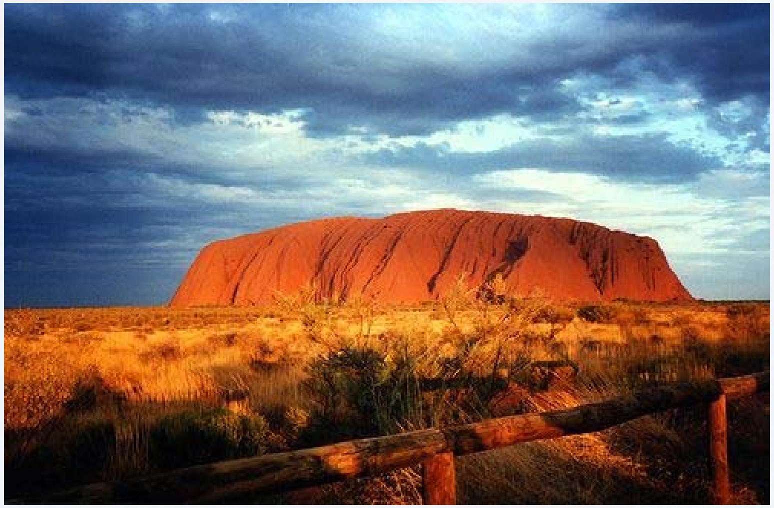
- The return to service program provided the newer operations members with the unexpected, but welcomed opportunity to participate in the ‘commissioning’ process, with valuable experience gained there from.

- The reactor achieved full power on 23 May 2008.

The Three Sisters, Blue Mountains, New South Wales, Australia

Staff Movement

- Shift work - disruption with family and social life.
- Career advancement elsewhere.
- Shift Managers who left were replaced by the more experienced Reactor Operators.
- New recruits to fill Reactor Operators positions, undergo prescribed training before accreditation.



Sunset at Uluru
The sandstone formation stands 348 m high with most of its bulk below the ground, and measures 9.4 km in circumference.

Staff Movement

- Those who left were given the choice to maintain their accreditation as a Shift Manager or a Reactor Operator.
- To do that, they have to satisfy the requirement of being on shift duty for a certain minimum hours in a year.
- The availability of these additional members creates a bigger pool of accredited reactor operational personnel.
- Interchange-ability between engineering and operations sections - their knowledge and experience benefit
  - the work they perform in both the sections
  - the individuals in widening their personal experience.

Underwater view of coral and fish.
The Great Barrier Reef, Australia.

CONCLUSIONS

TECHNOLOGY TRANSFER

- Invaluable experience can be gained from the reactor designer/supplier during the course of the project.
- Future reactor operators should involve in the project as soon as practicable.

Training in INVAP, Bariloche, Argentina

CONCLUSIONS (cont.)

STAFFING

- Personnel management strategy for the operating organisation should be in place well before the commissioning activities; succession planning, recruitment of new personnel, or redeployment of existing personnel.

Pioneer group of Shift Managers, Reactor Operators and Plant Operators

CONCLUSIONS (cont.)

TRANSITION PLANNING

- If the new reactor is to replace an existing one, planning for the transition period is essential to ensure safe operation and adequate resources are available for both reactors during this period.

CONCLUSIONS (cont.)

TRAINING

- in additional to the prescribed comprehensive training program, the reactor operators will greatly benefit by:
  - their involvement in the project,
  - participation in document review,
  - in commissioning activities.

Australian Rules Football

CONCLUSIONS (cont)

BUSINESS MANAGEMENT SYSTEM

- provides a framework under which the organisation could operate in an efficient, effective and consistent manner.

Efficiency

Effectiveness

Consistency

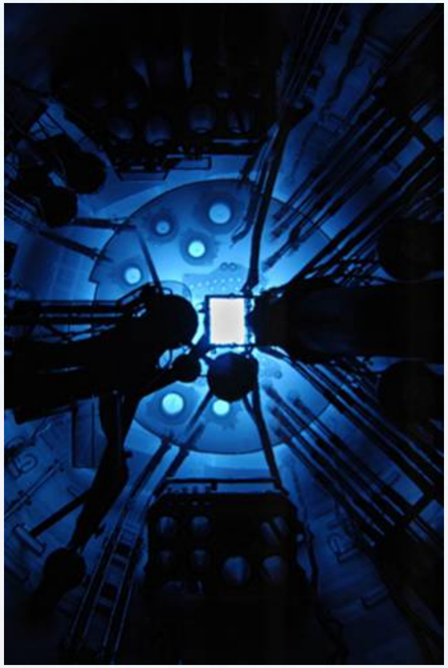
CONCLUSIONS (cont.)

ENHANCE SAFETY

A new reactor is also an opportunity:

- to reinforce/improve/change the culture of the organisation;
- to instil in the operators the good practices of the past; and
- to encourage innovative actions to enhance safety.

Epilogue



The 'blue' glow of OPAL

- The reactor is now in its 18th operating cycle.
- More neutron beam instruments are being commissioned.
- Increasing use of the irradiation facilities.
- We have learnt a lot about the reactor over the last three years.
- A few issues still need to be resolved.
- We believe OPAL is living up to be one of the best research reactors in the world.

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Nuclear-based science benefiting all Australians

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Thank you