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

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INTRODUCTION

There are two main reactors in ANSTO: HIFAR and OPAL. HIFAR was a 10 MW DIDO type reactor with heavy water in a closed tank. The heavy water acts as the primary coolant and also as the moderator. HIFAR was commissioned in 1958 and was finally closed down on its fiftieth year of operation in January 2007. HIFAR was replaced by OPAL – an open pool type multi purpose reactor with a thermal power of 20 MW.

OPAL achieved first criticality on 12 August 2006.

OPAL PROJECT – EARLY DAYS

I joined the OPAL project team when it was first formed in the late nineties, and helped to prepare some of the systems requirements. The successful tenderer for the replacement reactor was INVAP of Argentina. ANSTO and INVAP were determined to achieve the best outcome in the final product, that is, to design and operate a modern, state-of-the-art multi-purpose reactor.

I spent several weeks in INVAP headquarters in Argentina working with INVAP engineers during the design stage. This provided me with a better understanding of the design concept of the reactor; at the same time I was able to develop friendship and goodwill with the INVAP personnel.

TRANSITION FROM HIFAR TO OPAL

Experience

I started my career in ANSTO as an Operations Engineer in HIFAR. HIFAR has been operating safely for nearly fifty years and has developed a pool of very experienced reactor operators; including engineering, maintenance, operational and other support staff. It was intended to harness some of this expertise in nuclear reactor operation and to transfer the skills and knowledge from HIFAR to the new replacement reactor.

As there would be a period of dual operation when both HIFAR and OPAL were operating simultaneously, it was essential to maintain a sufficient number of staff to continue operating HIFAR safely and also to able to release some of these staff from HIFAR for training in the OPAL systems which are very different to those of HIFAR in terms of design and technology.

ANSTO created an OPAL Commissioning Operating Organisation to manage the recruitment and training of operations staff and to manage the operational aspects of commissioning.

Expressions of interest were invited from ANSTO staff to join the OPAL Commissioning Team. Apart from HIFAR staff, engineers and scientists from ARI, Safety and Environment divisions indicated their eagerness to be involved in the very exciting phase of the project. Successful staff were seconded to the Organisation.

These included a batch of nine recently graduated engineers and scientists who were recruited in early 2003 with the intention of them working in the new reactor project. Their initial training included on-shift training in HIFAR and taking part in HIFAR engineering and maintenance projects. Subsequently they were involved in OPAL documentation review and took part in OPAL training in INVAP headquarters in Argentina. By the commencement of OPAL commissioning in 2006 these engineers and scientists have had more than three years of working experience in a nuclear environment.

OPAL Training and Accreditation

A total of about 30 staff members underwent a comprehensive five-month training program on OPAL reactor design and operation. The trainees included a wide spectrum of personnel who would be working under the OPAL organisation. There were managers, engineers, maintainers, nuclear physicists, health physicists and several HIFAR operators. Out of these trainees about half would eventually become reactor operators and shift managers. The rest took up other roles in the OPAL organisation.

Before and during the training, members of the Operations Commissioning team were assigned to specific systems and assisted the project team members during the construction and early commissioning phases. The reactor systems are divided into groups as follows:

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 operations team members helped in the tests to verify and validate plant performance. During this time there were further interactions between the INVAP and Operations staff; this further improved our previously established good relationship with the INVAP personnel. The operations team members' intimate involvement with the plant and equipment during this period reinforced the understanding of the reactor systems.

At the end of the training, eight were accredited as Shift Managers. Several of these have had many years of experience in the nuclear industry, either in HIFAR or in other roles in safety or radioisotope production. One became the Operations

Manager. The Shift Managers and accredited Reactor Operators formed the shift crews. The final make-up of the shift personnel was a balance of experience and early career enthusiasm. All have undergone systematic and intensive training and duly accredited in their respective roles.

Some of the HIFAR Operators who joined OPAL were trained initially as Plant Operators – a transitional position for taking care of the external plant and under the instruction of the Reactor Operator. To make up the required complement, more staff were selected by an internal and external recruitment process. They all underwent specific training; at the end of which successful candidates were authorised to perform duties as Plant Operators. Over time these Plant Operators were given additional training and were successfully accredited as Reactor Operators.

The following table shows how the personnel were managed during the transition from HIFAR to OPAL operation.

OPAL Positions	During Commissioning	Staff Movement	Today
Operations Manager	Shift Manager 1		Shift Manager 1
Shift A			
Shift Manager	Shift Manager 2	IAEA	Shift Manager 4
Reactor Operator	Reactor Engineer	OPAL Engineering	Ex-HIFAR Operator
Plant Operator	Reactor Engineer	Resigned	External recruit
		External recruit	Shift Manager 12
Shift B			
Shift Manager	Shift Manager 3		Shift Manager 3
Reactor Operator	Shift Manager 4	Shift A SM	Ex-HIFAR Operator
Plant Operator	HIFAR Operator		Ex-HIFAR Operator
		External recruit	Reactor Engineer
Shift C			
Shift Manager	Shift Manager 5		Shift Manager 5
Reactor Operator	Reactor Engineer	OPAL Operations	Ex-HIFAR Operator
Plant Operator	Ex-HIFAR Operator		Ex-HIFAR Operator
Shift D			
Shift Manager	Shift Manager 6	OPAL Engineering	Shift Manager 7
Reactor Operator	Shift Manager 7	Shift D SM	Reactor Engineer
Plant Operator	Reactor Engineer	Activation Analysis*	Ex-HIFAR Operator
		External recruit	Shift Manager 11
Shift E			
Shift Manager	Shift Manager 8	OPAL Engineering	Shift Manager 9
Reactor Operator	Reactor Engineer	Shift Manager 9	Ex-HIFAR Operator
Plant Operator	Retired Ex ANSTO	Retired	Ex-HIFAR Operator

*Shift Manager 10

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. Hence the Reactor Operators will alternately perform the role as Plant Operators. The interchange-ability of these two positions not only provides flexibility in personnel management, but also enhances safety of reactor operation with their hands-on involvement with the plant.

Safety Culture

One of the objectives of the OPAL operations team was to establish a culture where team members will contribute to a work environment that is safe, professionally challenging and positive, and promotes teamwork in a manner that is cooperative and respectful. We wanted to assimilate the good practices of HIFAR and at the same time it is our desire to further enhance the emphasis on safety. All team members were encouraged to apply the STAR (Stop-Think-Act-Review) principle in carrying out their everyday activities and the activities are performed in strict adherence to approved procedures. The *Business Management System* helps towards achieving this objective. I am happy to say that the current practices contribute to enhancing the safety culture in OPAL.

Business Management System (BMS)

The use of the BMS assists with safe operation of OPAL and the BMS 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.

OPAL attained ISO 9001:2000 and ISO 14001:2004 accreditations prior to commissioning and 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

Stage A tests consist of complete system integration tests following pre-commissioning tests.

Stage B commissioning commences with the progressive loading of the fuel into the core and taking the reactor critical for the first time. 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. 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 and 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.

The commissioning tests continued with a series of low power tests aimed at demonstrating the functionality of the shutdown systems and the measurement of neutronic parameters including control rod calibrations. These tests turned out to be an intense learning period for the operation staff. The multiple start-ups and shut downs of the reactor for these activities were like condensing many reactor operating cycles into a very short period; thus providing opportunities for every operations staff to experience the various behaviours of the reactor systems under controlled conditions. We were able to ‘feel’ the response of the reactor control system when reactivity was increased or decreased with the different control rods withdrawn from or inserted into the core during the control rods calibration.

PROBLEMS DURING INITIAL OPERATIONS

Since commissioning, there were two events which significantly affected reactor operation. The first one is the light water ingress into the Reflector Vessel degrading the isotopic purity of the heavy water. The second is the problems associated with the Fuel Assemblies.

Leak in Reflector Vessel

It was determined that 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.

Fault in Fuel Assembly

The problem associated with the Fuel Assemblies caused the reactor to be shut down for a period of about 10 months.

The fuel fault was 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. The resulting investigation revealed problems with the fuel design (no secondary stopper), and other contributing factors.

The design of the Fuel Assemblies was modified to include a stopper to limit longitudinal movement of the fuel plates within the Fuel Assemblies. The stoppers provide a defence-in-depth feature that prevents significant fuel plate displacement in the Fuel Assemblies.

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.

Reactor Operation during this Period

While the fuel fault problems were being investigated and modification of the fuel assemblies undertaken, opportunity was taken to repair the leak in the Reflector Vessel. Several remedial solutions were attempted. The actions 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.

During the 10-month shutdown period of the reactor, the Operations staff helped in the investigative tests to determine the cause of the fuel fault and performing operational tasks during the repair of the Reflector Vessel. In addition the staff continued to operate and maintain the unaffected systems such that the systems were fully functional. All OLC requirements of the reactor were strictly complied with; and all OLC surveillance requirements were performed as applicable to an operating reactor.

The return to service strategy was to demonstrate the operational readiness of the plant. The program incorporated those 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 return to service program provided the newer operations members with the unexpected, but welcomed opportunity to participate in the ‘commissioning’ process, with the valuable experience gained there from.

The reactor achieved full power on 23 May 2008.

Shift Work

For many of my colleagues and I, we consider the involvement in the reactor commissioning as a once-in-a life-time opportunity. What could be closer to the hands-on actions than a position as a Shift Manager or a Reactor Operator?

However, not everyone is suitable for working shift. The exciting period of commissioning was followed by a stable period of operation. That was when some of the operations staff found that shift work affects them not only socially but also physiologically and wanted to opt out of shift work. At the same time there were others who were leaving for career advancement elsewhere.

Shift Managers who left were replaced by the more experienced Reactor Operators, via the normal selection and accreditation process. Their vacancies in turn were filled by new recruits who after going through the prescribed training were accredited as Reactor Operators.

Those who left to take up day work position in OPAL engineering and maintenance section were given the choice, if they so desired, to maintain their accreditation as a Shift Manager or a Reactor Operator. To do that, in addition to their normal duties, 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. It is intended to expand this interchange-ability between the engineering and the operations sections; their knowledge and experience not only benefit the work they perform in both the sections but also benefit the individuals in widening their personal experience.

CONCLUSION

(1) Invaluable experience can be gained from the reactor designer/supplier during the course of the project. Future reactor operators should be involved in the project as soon as practicable.

(2) 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.

(3) 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.

(4) 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 and in commissioning activities.

(5) A Business Management System provides a framework under which the organisation could operate in an efficient, effective and consistent manner.

(6) A new reactor is also an opportunity to improve/change the culture of the organisation; to instil in the operators the good practices of the past and encourage innovative actions to enhance safety.

The reactor is now in its 18th operating cycle. More and more neutron beam instruments have been commissioned, and with increasing use of the irradiation facilities. We have learnt a lot about the reactor over the last three years. Although there are still a few issues to be resolved, we believe OPAL is living up to be one of the best research reactors in the world.