REACTOR OPERATIONS AT SAFARI-1

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ABSTRACT

A vigorous commercial programme of isotope production and other radiation services has been followed by the SAFARI-1 research reactor over the past ten years – superimposed on the original purpose of the reactor to provide a basic tool for nuclear research, development and education to the country at an institutional level. A combination of the binding nature of the resulting contractual obligations and tighter regulatory control has demanded an equally vigorous programme of upgrading, replacement and renovation of many systems in order to improve the safety and reliability of the reactor. Not least among these changes is the more effective training and deployment of operations personnel that has been necessitated as the operational demands on the reactor evolved from five days per week to twenty four hours per day, seven days per week, with more than 300 days per year at full power.

This paper briefly sketches the operational history of SAFARI-1 and then focuses on the training and structuring currently in place to meet the operational needs. There is a detailed step-by-step look at the operator's career plan and pre-defined milestones. Shift work, especially the shift cycle, has a negative influence on the operator's career path development, especially due to his unavailability for training. Methods utilised to minimise this influence are presented. The increase of responsibilities regarding the operation of the reactor, ancillaries and experimental facilities as the operator progresses with his career are discussed.

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1 Introduction

SAFARI-1 is an MTR type tank-in-pool research reactor with a licensed operating power of 20 MW and is located at Pelindaba, Pretoria, South Africa. The reactor is a major producer of medical and industrial isotopes for both domestic and international consumption, the production of which is organized on a commercial and contractual basis. The reactor has been operational for ~37 years and has been affected in this time, as many research reactors have, by extreme swings in reasons and purpose for its existence, outdated or obsolete technology, aging of components and personnel, politics, changing public and regulatory demands regarding safety and risk of operation and numerous other factors of varying impact.

2 Reactor History.

Figure 1 depicts the power history of the reactor from 1965 to date.

The SAFARI-1 reactor project was first initiated in September 1960 and construction started in 1961. The reactor was commissioned in March 1965. Initially the secondary cooling capacity was 6.75MW and the reactor was operated as such. During 1968, significant upgrades were made to the reactor secondary circuit, allowing the maximum reactor power to be increased to 20MW.

In 1976 an embargo was placed on the supply of fuel to SAFARI-1. The operating power was reduced to 5MW and the operating hours greatly curtailed (at one stage four days every week) in order to conserve fuel stocks while a local enrichment and fuel manufacture capability was developed. In 1981 the first locally produced fuel assemblies became available and the reactor was operated for five days a week at 5MW until 1993. In 1993 the focus of SAFARI-1 operations was shifted to commercial applications. The nominal power level was increased initially to 10MW with gradually more frequent operation at 20MW for the development and implementation of commercial programmes.

During the first half of 1988, the reactor was shut down for 6 months to repair a pool leak.

The reactor is currently operated at the minimum power level required to meet commercial requirements, at an annual average of 17.8MW. It is worthwhile to note that the reactor reached its 1st million MWH in December 1994 after 29 years of operation. The 2nd million MWH milestone will probably be reached late in the third quarter this year (2003) after only 9 further years of operation. The reactor is currently run with availability approaching 90%.

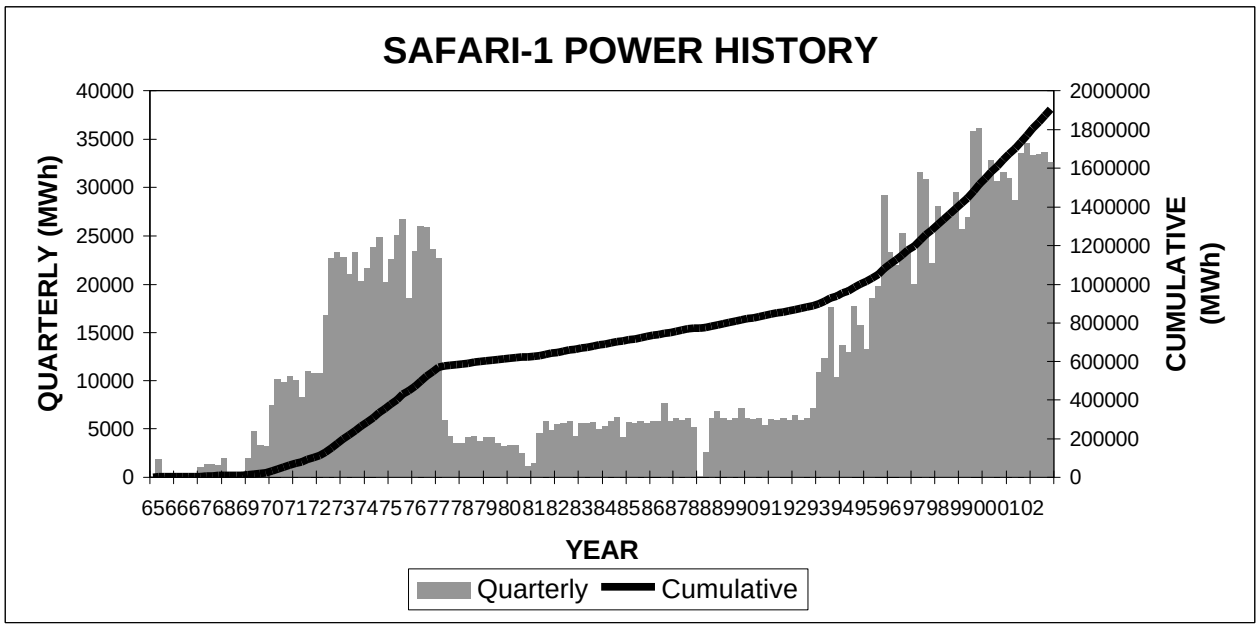

Figure 1: SAFARI-1 Power History.

3 Training and career path

To operate the facility reliably for more than 300 days per year requires a well-trained and dedicated operations team. Specialised training staff, consisting of two members, does all training of Reactor Operations (RO) personnel in-house. One member is a dedicated to the theoretical subjects and the

other, who is a licensed operator, is dedicated to the practical training on the plant and experimental facilities. A certain degree of training is also received on shift and is mostly coordinated by the shift supervisor. All training in the facility is done under the control of the Reactor Training Committee.

Shift work has some negative effects on the availability of personnel for training and special provisions are in place to minimise this effect. Trainees receive practical training worksheets that must be completed while on normal shift duty. The trainee may not partake in any examinations before these worksheets are completed. The shift roster itself is set up in such a way that it allows four days of the cycle for training purposes. If training does not require all this time, the personnel are utilised to do specific low-frequency maintenance tasks.

3.1 Reactor Training Committee

A Reactor Training Committee (RTC) was established with the primary responsibility of participating in the assessment of the training, development and evaluation of personnel and to oversee the effective training and re-training of SAFARI-1 reactor operators and other personnel. The RTC has set a pass-mark of 70% on all theoretical examinations and 80% on practical or panel examinations. A diploma, endorsed by the Manager: SAFARI-1 Research Reactor is issued to all levels of RO personnel upon obtaining a specific licence or qualification. The RTC may withdraw a candidate's certificate of qualification if he is guilty of any misconduct, negligence, or the wilful violation of any operating procedure or licence condition. The RTC may specify conditions that the candidate must fulfil before his certificate can be re-instated (e.g. re-training, re-examination, etc.). The expected conditions of achievement with respect to required standards of examination are issued in a training manual made available to each shift worker. The requirements of these training programmes are assessed and approved by the local National Nuclear Regulator.

3.2 Staff Selection and Career Path

RO staff is appointed from the available workforce after extensive psychometric testing and interviews. All training is presented in-house and no university or college qualification is required.

The career of the operator is subdivided into the following well-defined steps:

- Learner reactor operator
- Plant operator
- Licensed reactor operator
- Senior licensed operator
- Shift leader
- Probational shift supervisor
- Shift supervisor
- Assistant head RO
- RO Manager

Operators are trained in a chain of progression through the various steps, each step being a prerequisite of the following.

3.2.1 Learner Reactor Operator

To be appointed, the candidate must comply with a minimum requirement of a secondary school certificate or equivalent with appropriate symbols in Science and Mathematics, unless otherwise recommended by the RTC. A learner reactor operator is appointed on a contract basis for the first 9 months of training. The learner has no defined plant related responsibilities other than to study. He may however perform selective tasks under direct supervision in order to gain experience.

3.2.2 Plant Operator

To qualify as plant operator, the learner reactor operator must acquaint himself with 28 subjects that are further sub-divided into 75 modules. Most of these are written examination subjects and include all reactor processes and experimental facilities. On successful completion of the theoretical training, the candidate receives a financial recognition for his effort. The increment received is based on the aggregate of the theoretical subjects and is applied as follows:

- Aggregate in the range 70 - 80% 7% increase
- Aggregate in the range 80 - 90% 10% increase
- Aggregate in the range 90 - 100% 12% increase

After completion of the theoretical training the candidate is subjected to a period of not more than 15 months practical training. During this time (when the candidate is ready), core members of the RTC

verbally examine the candidate during a physical walk-through of the plant. On successful completion of this examination, the candidate is appointed as a plant operator with the responsibility of operating / manipulating all plant related equipment and selective experimental facilities. The larger and more complicated experimental facilities are still operated under supervision. The average time to qualify as a plant operator is 12 months.

On obtaining the plant operators qualification, the candidate is again rewarded financially as described before. In addition to the financial incentive, he is promoted to the next post level.

3.2.3 Licensed Reactor Operator

The qualified plant operator undergoes a further period of not less than six months and not more than nine months, theoretical and practical training covering eight subjects in 47 modules. After completion of the required theoretical examinations, core members of the RTC verbally examine the candidate during a panel examination, to satisfy themselves that the candidate possesses the required knowledge and also essential understanding of the subjects. After successful completion of the theoretical and practical training, the candidate must execute a reactor start-up examination to prove his ability in the control room. When successful, the candidate is appointed as a Licensed Reactor Operator, with the added responsibility of manning the control room and performing the necessary manipulations. At this level, most tasks can be performed without supervision, if the operating procedure of the facility does not specify otherwise. The licensed operator must supervise the Learner- and Plant Operators when performing tasks as a team.

On obtaining an operating license, the candidate is again rewarded financially as described before. In addition to the financial incentive, he is promoted to the next post level.

All operators in SAFARI-1 must be fully licensed operators as no allowance is made for dedicated reactor operators or experimental operators, only all-rounders. Therefore, a maximum limit of 9 months is placed on the obtaining of an operating license, after obtaining plant operator status. Should an operator not be able to obtain an operating licence in this period, his career is re-evaluated by the RTC and he may be reallocated to another department.

3.2.4 Senior Licensed Reactor Operator

A licensed reactor operator may, after gaining experience for a minimum period of two years, take part in the senior training programme. In this programme, 13 subjects are covered in 37 modules. After successful completion, the candidate may be appointed as Senior Licensed Operator. The senior operator may act as shift leader, should the shift leader not be present.

On completion of this phase, the operator is promoted to the next post level with financial recognition as previously described.

3.2.5 Shift Leader

This level is a special level applicable to candidates who have been identified by the RTC as potential trainees for the position of shift supervisor. To qualify as a shift leader, the senior licensed operator must have at least two years experience as a senior reactor operator. In addition to this, he must pass an entrance examination established by the RTC in the form of a panel examination that will test the candidates' knowledge on the process plant and reactor operations, in readiness for further training as a Shift Supervisor. After qualification, the shift leader has the added responsibility to arrange the day-to-day running of his shift on behalf of the supervisor. This gives him the exposure required to broaden his thinking and develop planning abilities.

On completion of this phase, the operator is promoted to the next post level with financial recognition as previously described.

3.2.6 Probational Shift Supervisor (PSS)

Although the teaching of theoretical subjects commences after completion of senior training, training as a PSS will generally only commence if a vacancy exists. At the discretion of the RTC, a licence may be granted without the existence of a vacancy, for selective purposes. To qualify for the final PSS examination, the shift leader must pass an entrance examination in the form of a panel and/or a theoretical examination with a minimum pass mark of 80%. The candidate must also complete additional theoretical courses and have at least three years experience as a shift leader or senior reactor operator

After successful completion of the written final examination, he undergoes a stringent panel examination in which an assessment of the trainee's knowledge on the full plant will be made. Special attention is given to the candidates' in-depth knowledge and understanding of the plant. After qualification, the PSS may act as supervisor on his own or another shift, when a shift supervisor is not present. The PSS is also promoted to the next post level and receives financial recognition as previously described.

3.2.7 Shift Supervisor (SS)

Appointment as a SS can generally only be made if a vacancy exists. Six months experience, as a PSS, is required before a candidate can be considered for promotion. The RTC will assess the candidate and make a final recommendation to line management regarding an appointment as shift supervisor. Upon appointment the SS is promoted to the next post level and receives an increment in salary.

The shift supervisor is responsible, directly to the RO Manager, for the safe and effective operation of the facility in accordance with set targets and within the scope of the licence. All work carried out on the reactor or ancillaries may only be performed after obtaining permission, in the form of a works permit, from the SS and only after he has evaluated the influence a task may have on the rest of the plant and facilities.

4 Re-training

In order to maintain the high levels of competence, all RO personnel are subject to a continuous re-training and qualification programme. To enforce this programme, all RO licenses issued by the RTC are valid for a maximum period of two years. All RO personnel are required to be re-examined and re-licensed before their licenses expire. During this two-year period, practical worksheets have to be completed in order to gain admittance to a panel examination.

Should an operator fail to obtain a licence during re-examination, his level of authorisation is reduced to the next lower level. A second attempt is allowed within one month. If unsuccessful, his licence is withdrawn and he must repeat the appropriate training programme to regain his qualification. If he continues to be unsuccessful, the operator may ultimately be reallocated to another department through formal disciplinary steps.

5 Shift Structure

The RO department consists of one manager, an assistant head and 30 other members. Details of the structure of the department are given in figure 2.

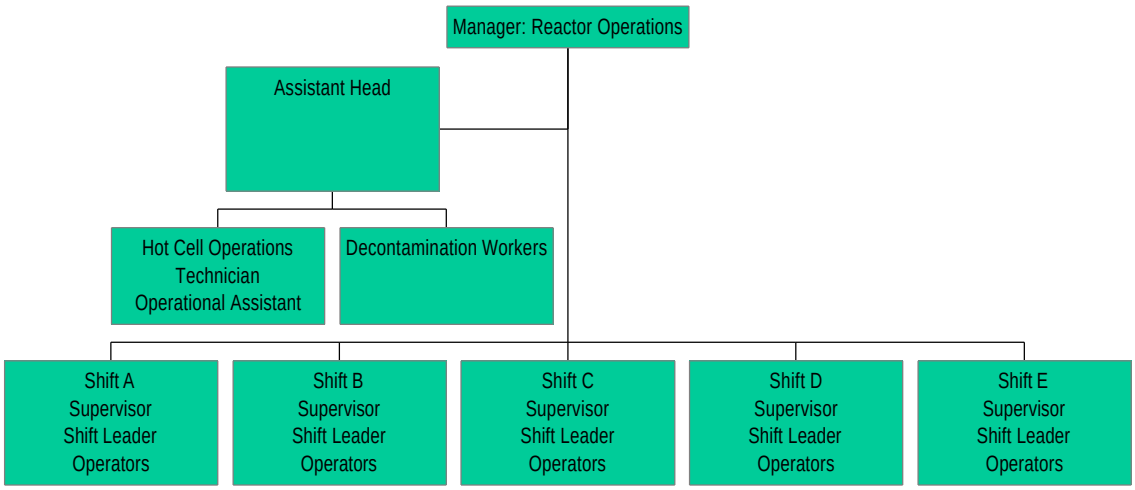

Figure 2: RO Organisational Structure

Each shift consists of a Supervisor, Shift Senior, and three other members ranging from Senior Licensed Operators to Learner operators. One member of each shift is a qualified Radiation Protection Monitor, who is authorised to monitor small radiological tasks as required from time to time.

6 Shift Cycle

The RO personnel are allocated on a five-shift system with a shift cycle of 35 days, ensuring continuous manning. The shift cycle is graphically displayed in figure 3. A normal shift is 8.5 hours long, and is from 06:45 to 15:15 (dayshift); 14:45 to 23:15 (afternoon shift); 22:45 to 07:15. The 30-minute overlap of shifts allows time for shift changeover to ensure a seamless transition.

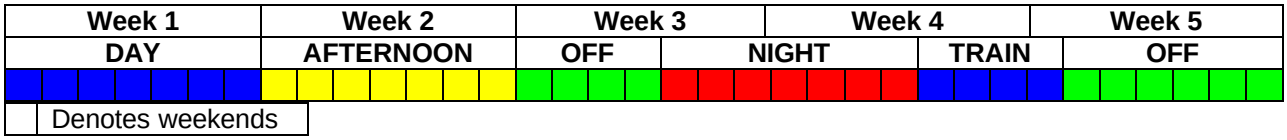

Figure 3: SAFARI-1 Shift Cycle

The longer periods on a specific shift are found to allow more physical stability, giving personnel a day or two to adjust to the new hours after every shift change. The shift selections are made to specifically balance shift abilities and to manage personality incompatibilities.

7 Conclusion

The efforts put into the training of reactor operations personnel has been shown to have a positive contribution to the efficient operation of SAFARI-1. Operator training is done in-house at a high standard. All theoretical examinations and practical tests have high pass requirements and all efforts of the students are recognised financially. The unique shift structure allows continuous retraining as well as greater stability and flexibility. The multitasking of personnel results in increased personnel economy.

SAFARI-1 has regularly demonstrated its success in the dual role of providing reliable services as a national asset to South Africa, at the same time, providing neutrons for the backbone of a very successful commercial enterprise. This has been achieved by careful evaluation of operational needs and the implementation of supportive development of operators according to the desired technical standards.