

SAFARI-1 SAFETY REASSESSMENT AND MODIFICATIONS IN LIGHT OF THE FUKUSHIMA DAICHI ACCIDENT

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Abstract

Following the Fukushima nuclear accident, a directive from South Africa's National Nuclear Regulator was received which required a safety reassessment of the SAFARI-1 research reactor.

The safety reassessment consisted of:

- Evaluation of the response of the SAFARI-1 Research Reactor when facing a set of extreme external events (EEE) or Design Extension conditions and
- Verification of the preventive and mitigation measures chosen following a defence-in-depth (DiD) logic: initiating events, consequential loss of safety functions, severe accident management.

The safety reassessment process was performed in various steps. Site-specific natural external events (Design Extension conditions) were firstly identified. The full lists of EEES identified that may have an impact on SAFARI-1 include earthquakes, external flooding, tornadoes and tornado missiles, high winds, sandstorms, storms and lightning, hurricanes and tropical cyclones, bush fires, explosions, toxic spills, accidents on transport routes, effects from adjacent facilities, biological hazards, and power or voltage surges.

For the set of situations proposed, a deterministic approach was used in which the sequential loss of the existing lines of defence is assumed, regardless of their probability of occurrence. The ultimate objective was to confirm the degree of suitability of the existing measures for accident management and, finally, to identify potential applicable improvements regarding both equipment (fixed and portable) and organisation (procedures, human resources, emergency response organisation and use of off-site resources).

This step was followed by the development of event trees which depict the progressive evolution of the EEE into plant damage states which could potentially lead to public exposure. These evaluations were carried out in accordance with the philosophy of DiD as proposed in the ENSREG stress test specification.

A number of recommendations were identified by the safety reassessment feasibility investigations, including stabilisation of fresh fuel store, emergency water return, external plugin power, re-flooding nozzle, emergency control room, independent seismic trip, second shutdown system, reactor building reinforcement and updating emergency procedures. Most of the recommendations have been taken to the implementation phase.

This paper will present the *summary of feasibility phase* outcomes, *results of the safety reassessment*, as well as some of the progress on resulting modifications and the future operations to conclude the post-Fukushima safety enhancements activities.

1 Introduction

Following the Fukushima nuclear accident, all operating nuclear plants worldwide underwent thorough scrutiny to consider their safety under extreme events. A safety review of the SAFARI-1 research reactor on Necsa's site was conducted to conform to the National Nuclear Regulator (NNR) directive on safety reassessment following EEE.

1.1 Overview of Reactor

SAFARI-1 is a tank-in-pool type research reactor of similar design to the Oak Ridge Research Reactor (ORR). It has one unit operating at 20 MW thermal power. SAFARI-1 is a high neutron flux, light-water-moderated and cooled, beryllium and light water reflected research reactor designed and built as a general research tool, falling in the class of research reactors commonly known as Materials Test Reactors (MTRs).

1.2 Prominent Features of the Reactor

1.2.1 Reactor Primary System

The reactor primary system is fully enclosed and circulated separately from the pool system. The reactor vessel is fully submerged in the reactor pool, with the vessel top about 4 m below the pool surface and the core at about 7.5 m below the pool surface.

1.2.2 Pool Structure

A prominent feature of the reactor building is the pool structure, which comprises three pools separated by removable gates; the reactor pool (where the reactor vessel is located), the spent fuel pool (SFP) and the canal pool. The reactor pool and SFP are in the reactor hall and form part of the confinement area, while the canal pool is a part of the laboratory area.

1.2.3 Confinement System

The reactor building is not a containment structure. Confinement of releases is controlled by means of active ventilation systems, which maintain a negative pressure in the reactor hall with respect to the environment to ensure no outward leakage.

1.2.4 Heat Sink

The heat sink, to which the heat from the reactor core, reactor vessel and SFP is transferred, consists of the reactor primary system and the pool primary system from where the heat is transferred through shell and tube type heat exchangers to the secondary system. Heat is dissipated to the atmosphere from the secondary system via forced convection wet cooling towers.

1.2.5 Features of SAFARI-1 Related to its Siting, Behaviour and Resistance during BDBA

The following features of SAFARI-1 enhance its resistance during beyond design basis accidents (BDBA):

- The Necsa site is situated in a region of low seismic activity;
- The Necsa site is situated far inland and at an elevation of 1330m above sea level;
- A combination of an earthquake and flooding is irrelevant for the Necsa site;
- It can survive an extended SBO without damage to reactor fuel or spent fuel;
- The reactor shuts down on external power loss even if RPS doesn't work;
- The fission product inventory is approximately 2 orders of magnitude less than an average NPP
- The fuel geometry is such that complete drainage of the spent fuel pool or the reactor vessel can be tolerated with only limited fuel damage;
- There is a bund in the building basement that has sufficient capacity to contain the entire pool and reactor primary system water content.

2 Safety-Reassessment Methodology

The safety reassessment process was performed in various steps and according to the ENSREG stress test specification. A comprehensive list of EEE were considered and screened according to site characteristics to identify a set of site-specific natural external events that may possible strike the site as identified in the full list mentioned above.

For the set of situations proposed, a deterministic approach was used in which the sequential loss of the existing lines of defence is assumed, regardless of their probability of occurrence. The ultimate objective was to confirm the degree of suitability of the existing measures for accident management and, finally, to identify potential applicable improvements regarding both equipment (fixed and portable) and organisation (procedures, human resources, emergency response organisation and use of off-site resources).

3 Results and Recommendations

In the 50 years of SAFARI-1 operation, no seismic event or severe adverse weather phenomena have been encountered at the facility that impacted nuclear safety or the safe continued operation of the reactor. The feasibility and effectiveness of accident management measures are however regularly tested during emergency exercises.

3.1.1 General Recommendations

An early severe weather warning notification system or arrangement could be investigated which could be beneficial to alert operators of approaching adverse weather conditions. Certain actions may then be taken, amongst others:

- Ensuring communication between SAFARI-1's control room and the Necsa site Emergency Services.
- Bringing the plant to a safe state before the any EEE strikes.
- Stopping the intake ventilation systems to ensure that a negative pressure difference between the radiological areas and the outside environment is maintained during a severe event challenging the confinement.
- Execution of the plant emergency procedures to take action as required (e.g. evacuating personnel from areas affected by the unavailability of intake ventilation systems).

The principles of safety categorisation and classification methodology in determining the safety classification of new SSCs that are added to the existing SAFARI-1 plant for implementation of the EEE is unsuitable. This is because the methodology requires evaluation of the "risk benefit" of the SSF (SSC Safety Function), which is based on estimation of the frequency and the radiation dose associated with the event. An estimation of the event frequency may be possible, but given the vast number of possible plant configurations following a beyond design basis EEE, the dose is impossible to quantify. As result an adaptation to the methodology was proposed to deal with these unsuitability.

3.1.2 Plant Modifications

The safety reassessment indicates that the following hardware modifications could be investigated to enhance the robustness of the plant against EEE:

- **Re-flooding nozzle:** The re-flooding of the reactor vessel along the existing re-flooding pathways can be fairly slow. The availability of an additional re-flooding path located in the vessel-top could be an improvement of the re-flooding pathways.
- **Racks in fresh fuel vault:** The rack stands could be bolted to the walls and the Fuel Elements (FE) and control rods could be clamped to the shelves to increase the robustness of the vault.

- **Seismic trip**, a pre-emptive trip of the reactor during a Beyond-Design Basis Seismic Event, to secure a full shut down of the reactor before sufficient damage to the shut-down system disables the ability of this system to function adequately. *The envisaged system at SAFARI-1 would consist of three tri-axial (X, Y, Z) sensor units fixed to the east, south and west sides of the biological shield structure within the reactor hall.* These sensors would be connected through a 2-out-of-3 voting logic system to interrupt the power supply to the control rod magnets, either at the 3-phase input to the magnet chassis or at each outputs from the magnet chassis to the control rod magnets.
- **Portable plug-in power supply system**, The plug-in points are installed at accessible locations outside the building where possible and, where there is a need to place them inside the building, they are located where they are easily accessible from outside by more than one route. Each plug-in point consists of a standard external plug socket mounted inside a secured (i.e. tamper proof) and weather proof cabinet to the designated wall of the facility.
- **Emergency Water Return Systems**, this is an alternative means to return cooling water, lost through possible breaches in cooling systems caused by a beyond design basis Extreme External Event/ design extension condition, to the reactor core and spent fuel that might otherwise become damaged due to overheating.
- **Second shutdown system**: An additional diverse shutdown capability independent of the control rods could also eliminate fuel damage in case of a large break LOCA in the reactor primary system subtended by a failure of the normal Scram system. The outcome of the assessment is a recommendation to pursue the progressive activation of several diverse “second shutdown actions” rather than a single system.
- **Additional diverse instrumentation**: The incorporation of additional dedicated monitoring instrumentation may be an advantage. Instrumentation may include, but is not limited to: independent core monitoring instrumentation, radiation monitors, exhaust air monitoring and a small portable electrical power supply to operate the instrumentation.
- **Submersible pumps**: It will be beneficial to have a number of submersible pumps at strategic places in the basement and process wing to pump water that has drained from a damaged pool wall back into the pool or reactor core.
- **Increasing robustness of building**: The robustness of the SAFARI-1 building can be improved by strengthening some structural components.

3.1.3 Status of the proposed plant modifications

3.1.3.1. Racks in fresh fuel vault

High level Requirements

According to a Safety Reassessment [1] conducted on the SAFARI-1 reactor facility, in the event of an earthquake or other EEE that may cause severe shaking of the fuel racks in the vault, the fuel assemblies and target plate boxes can be shaken out of the cradles and deposited onto the vault floor. A mechanism or means of restraining the fuel assemblies and target plate boxes is required to secure them on the cradles. Further investigation revealed that the cradles themselves are fastened to the racks by one self-tapping screw, and this needs to be remedied.

Proposed solution

The solution is to apply to the existing cradles, and must not necessitate a redesign of either the cradles or the rack they are situated on.

The mass of each item is defined in the Loading Catalogue. Given the mass and the accelerations, the maximum instantaneous forces on the items in the horizontal and the vertical directions are given in Table 1

Table 1: Maximum Instantaneous Forces on Cradle Contents

Item	Mass (kg)	Acceleration (m/s ²)		Force (N)	
		Horizontal	Vertical	Horizontal	Vertical
Fuel assembly	6.5	11.8	4.1	76.5	26.8
Target plate box	15			176.6	61.8

The horizontal force induced by the target plate box provides the greatest force, at 176.6 N.

The recommended factors for combining different loads during accident conditions were studied and defined. The load factors prescribed for self-weight, imposed loads, and seismic actions during accidental conditions are all 1.0, and therefore the forces determined above are applied in the relevant calculations without modification. A length of stretch cord with one end permanently fixed to the back end of the cradle, which is then wrapped around the item in a prescribed configuration, with the other end hooked into a plate at the front of the cradle.

The nominated final solution completely restricts all uncontrolled motion of the fuel assembly during the maximum instantaneous EEE acceleration suggested, and allows a controlled horizontal displacement of less than 11 mm of the target plate box, which is then returned to its original position due to the restorative force applied by the elastic cord. The solution satisfies all other requirements prescribed in the Requirements Specification [3].

The proposed solution also investigated the sources of fire loading, the probability of the occurrence of fire in the vault and how it will be mitigate. On assessing the risk of fire in the vault, and preventing the ingress of an external fire by examining and modifying the configuration of the doors from the passage as necessary, and removing possible sources of ignition in the vault.

3.1.3.2. Re-flooding nozzle

High level Requirements

The assessment report for Re-flooding Nozzle [4] indicated that system should consist of:

- Nozzles directed on the core (exact amounts and positioning needs to be specified);
- Elevation of the current gooseneck;
- Pipework to connect the nozzles to the pool water and to the emergency water return system and the pool;
- A means to enable (trigger) automatic opening to the nozzle in the event of loss of coolant in the reactor vessel (potentially bursting discs or floating ball valves);
- Siphon breakers in pipework to prevent drainage of pool water via gravitation from the pool to lower areas (or alternatives to prevent this).

The nozzle and siphon breaker setup will interface with the emergency water return.

Proposed Implementation concepts

Concept 1: Directing the Re-flooding Flow at an Angle

This concept uses one of the angled experiment ports in the upper part of the vessel, sourcing water either from the pool or from the emergency water return system. The nozzle creates a droplet spray in such a fashion as to cover most of the core top structure. Figure 1 shows a schematic of the arrangement using the 6” port, but the re-flood nozzle could equally be deployed through one (or more) of the 2” ports.

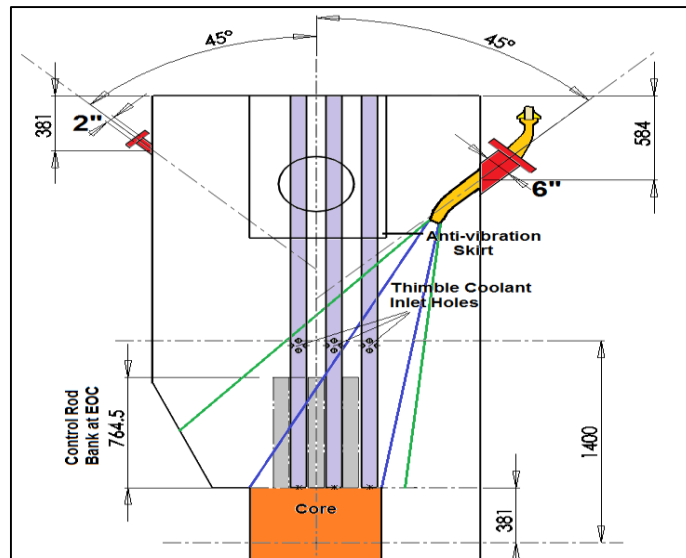


Figure 1 : Schematic of Concept 1 using the 6" Angled Experiment Port

From either of these ports, the spray would have to be directed at an angle with respect to the core.

Concept 2: Directing the Re-flooding Flow Straight from Above the Core

Using penetrations through the Perspex window of the hatch cover, this concept deploys one or more spray nozzles directing their spray vertically down onto the core, between the thimble tubes. The nozzle(s) can be installed in such a way so as to provide sufficient coolant spray to the control assemblies at any extent of withdrawal. Figure 2 shows a schematic of the arrangement.

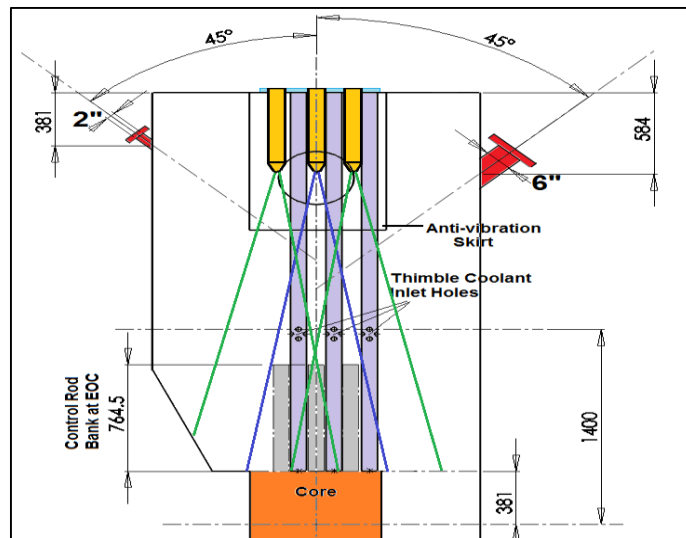


Figure 2 : Schematic of Concept 2 using Penetrations through the Hatch Cover

This concept improves the re-flooding nozzle spray access to the core (as compared with Concept 1); however the thimbles still obstruct “line-of-sight” with some of the fuel element positions in the core. This should not be a serious drawback, however, as it is expected that the spray flow would curve around the obstructions without any decrease in density by the time it arrives at the top of the core. This can also be tested in a simple experiment.

In summary, the main advantage of this concept is:

- It results in a more direct coverage of the core itself, including the control rod assemblies, as compared with Concept 1.

The disadvantages are the following

- The flow of cooling water into the thimbles for cooling the target plates is uncertain,

- Engineering a solution to this problem would require a re-design of the thimble sections above the core,

Space at the vessel top is severely constrained and could eliminate this concept as an option

Concept 3: A Grid of Spray Nozzles above the Core

This is a variation of Concept 2, in which the spray is still provided from directly above the core at the reactor vessel top, but is distributed through a grid of nozzles connected to a manifold. The main idea behind this concept is to overcome the geometrical obstruction posed by the thimble tubes, as observed in concept 2 by introducing a separate spray into each space between the thimbles. In this way each fuel assembly and control assembly is supplied with a dedicated source of cooling.

Concept 4: Tapping into the Existing Emergency Spray Nozzle

The existing emergency spray nozzle, which is supplied from a process water source in a cubicle outside the reactor building, complies with the size limitations that emerged from the analysis. Its location in the vessel and its orientation and size therefore do not differ materially from the re-flooding nozzle proposed in Concept 1. It is therefore a strong candidate for this application, provided that a means can be found to accommodate a pool water inlet and return water inlet to the supply pipe of this nozzle.

3.1.3.3. Emergency Water Return Systems

Alternative mechanisms to collect water are using mostly existing structures such as the catchment areas of the reactor basement and process wing and the low-active waste tanks buried to the south of the building, are investigated and developed with the objective of providing operators and emergency functionaries with multiple fall-back options to deal with possible fuel damage due to loss of cooling after an EEE. The currently installed emergency core cooling equipment at SAFARI-1 consists of the following:- Two pumps, show below in Figure 3; in parallel with the main primary pumps, supplied from separate UPSs each with separate battery and separate diesel backup.



Figure 3 : Pump Room, Showing the Emergency Core Cooling Pumps (the two outer pumps) and the Decay Heat Removal Pump (the middle one)

One of these pumps runs continuously while the reactor is in operation (without delivering against the head of the primary pumps) so that, on loss of the primary pumps with the reactor at power, there is an uninterrupted forced flow transition from operational to emergency flow. The other pump can be started at any time from the control room or locally. These two pumps are called “Shut-down Pumps” although, in more common modern terminology, they fulfil the role of emergency core cooling pumps. One of these pumps alone supplies sufficient down-flow forced cooling through the core for indefinite post-scrum cooling.

A third pump (the middle pump in Figure 3 above, this pump (also called a Shut-down pump) is normally operated when the reactor is shut down for maintenance and fulfils the role of what, again in more common modern terminology, would be called a Decay Heat Removal pump. A spray nozzle installed in the reactor vessel which is connected by means of a pipeline to a cubicle situated outside the reactor building near the access door to the process wing adjacent to the pool heat exchanger. In the event of core uncover operations staff need to physically connect this pipe to a process water connection point within the cubicle, by means of a short length of fire hose provided for the purpose, then the water flowing through the nozzle then sprays down on the core, providing both adequate cooling as well as re-flooding of the core

Each of the UPS-supplied Shut-down pumps is therefore, on its own, capable of providing continued forced convection cooling of the core on loss of off-site electric power, with the associated loss of flow from the main primary pumps, while the emergency spray nozzle is intended for providing a means to cool the core as well as to re-flood it when there has been a major loss of coolant in the reactor primary cooling system.

3.1.3.4. Seismic trip

In SAFARI-1 the existing protection from a seismic event relies on the usual suite of nuclear and process instruments to detect disturbances in the core or primary system exceeding given set points and to generate a Scram action through the Reactor Protection System. The response to a seismic event is therefore indirect and non-pre-emptive, and the reactor will only shut down if the seismic event has caused some disturbance in the core or the plant that exceeds a trip set point.

Examples of such disturbances that may accompany a seismic event are the loss of electric power to the primary pumps (causing a loss of coolant flow through the core and a low flow or low core ΔP trip), sufficient disturbance of the core geometry or an in-core experiment to cause a reactivity insertion (and a reactor high power or low period trip), breach of a primary coolant line leading to a loss of coolant (and a low core ΔP trip or one of several other trips) and the loss of the secondary cooling system (leading to a high core outlet temperature trip). A loss of off-site power will immediately cause the control rods to drop, no matter what other disturbances do or do not occur, since the control rod magnets are supplied from off-site power. In a nutshell, if the seismic event does not lead to any such disturbance, the reactor will not shut down.

A weakness in this reliance could be that, if the seismic accelerations are high enough, the control rods may deform where they protrude above the top bearings, or they might jam in the actuator latching heads, the bearings, the grid plate or adjacent fuel elements, and although all the instrument trips may function correctly and generate a Scram actuation, the control rods may not be able to insert. This condition (failure of Scram) has been extensively analysed for loss of flow and loss of coolant accidents within the design basis in the SAFARI-1 Safety Assessment and it was shown that even when the control rods don't insert, the increase in fuel and coolant temperatures, or the loss of moderator, lead to an immediate power reduction without fuel damage, and the resulting build-up of ^{135}Xe in the core maintains an effective shut down state for a few days.

There are numerous international vendors of seismic monitoring and protection systems who have supplied nuclear facilities around the world, most notably nuclear power plants, with various levels monitoring and protection capabilities. Equipment ranges from single sensors positioned within the facility, providing only an alarm annunciation, to large arrays of sensors arranged in a predefined geometry in the ground around the facility and connected to the reactor Scram system through a voting logic.

It is recommended that a full specification be drawn up along the following lines so that a more meaningful interaction can be initiated with the respective service providers of the seismic trip.

- Three tri-axial accelerometers, to be mounted at three separate locations on the outer surface of the biological shield block of the reactor (or better locations advised by expert opinion).
- At least two adjustable trip functions for each axis of each accelerometer, one to provide annunciation in the control room of a condition approaching the Scram setting, and the other to provide input to the voting system to initiate a reactor Scram,
- Signal conditioning local to each accelerometer, with trip thresholds producing output capable of holding relays closed in the power supply to the magnet chassis,
- A hard-wired 2-out-of-3 voting system incorporating a system of the above relays,
- A facility for capturing trip events and times in the existing facility SCADA system,
- Compliance with the appropriate Quality Class requirements for the seismic Scram system, such as supplier qualification, system and technical audits, etc., as applicable.

The envisaged seismic Scram system will need to interface with the electrical power supply to the magnet chassis. While the magnet chassis is supplied from off-site power, the interposition of relays in the supply, in series with those of the normal Scram system, needs to ensure that the operation of the normal Scram system relays is protected from faults in the seismic Scram system.

3.1.3.5. Portable plug-in power supply system

In the event of an EEE that causes damage to the emergency electrical supply systems, the total loss of both off-site and emergency electrical power. A number of extreme scenarios were postulated. Important considerations in implementing measures to provide external plug-in power supplies were considered. The plug-in points are installed at accessible locations outside the building. The first approach is to supply power at the common points where the combined failure of offsite and Genset power is initially manifested, namely at the inputs to the UPSs (Option 1). Option-2 allows the ability to connect directly to the output cables from each UPS, enabling the selective provision of power even when the UPSs, or their supply cables, have been damaged beyond usefulness as shown in figure 4.

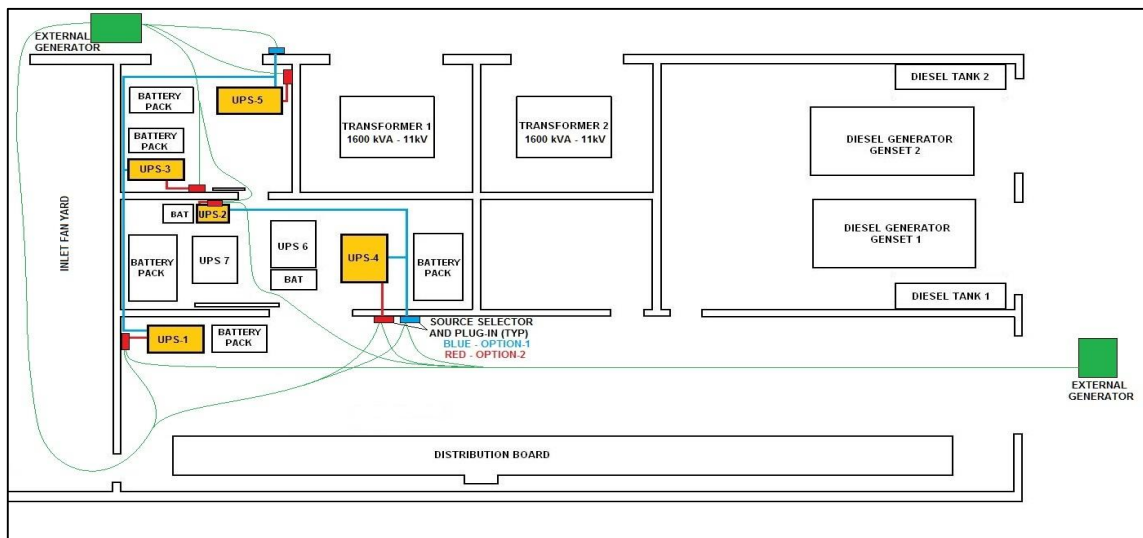


Figure 4 : Physical Layout of Electrical Wing Showing UPS and Diesel Generator Locations and plug in points

In option 1, the manual bypass switches incorporated into each UPS can be closed and the UPS switched off in order to remove the heat load of the UPSs, thereby making more power available for some of the supplementary functions. In option 2, all the plug-in points are inside the building in this, but are accessible through three separate routes from the portable power supplies outside.

A procedure would need to be followed by operations staff and/or emergency functionaries to establish, by direct observation and/or by indirect deduction from observable phenomena, the nature of the damage and the most appropriate deployment of the options recommended in this report. At a high level, such courses of action might include the following:

- i. If the diesels have failed to start, dispatch an operator to the diesel room to establish whether it is feasible to manually start at least one Genset.
- ii. If operation of the Gensets is not feasible, due to damage to the Gensets or the supply cables to the UPSs or to the UPSs themselves, dispatch two to four operators to open the most convenient container(s) outside and to deploy appropriate portable generators and cables to the UPSs – either by Option-1 or by Option-2.

Procedures need to be developed for the regular maintenance and inspection of all the mobile and portable equipment implemented according to the recommendations of this project, and for the periodic testing of the equipment and training of personnel/functionaries by means of simulation exercises.

3.1.3.6. Second shutdown system

The outcome of the assessment is a recommendation to pursue the progressive activation of several diverse “second shutdown actions” rather than a single system. Recommended concepts are grouped into three main categories, namely;

- Two methods using contained soluble neutron poison that can be triggered automatically and separately, each capable of immediately inserting sufficient negative reactivity to effect a prompt shutdown of the reactor,
- A further three methods that can be separately or collectively deployed (manually) within 60 hours after the EEE to ensure that the core does not return to criticality in the longer term when it cools down and when ^{135}Xe decays, and
- One last-resort measure, using an uncontained soluble neutron poison (i.e. it is added directly to the primary coolant in the core) that will ensure long-term safety if the collective measures of the previous two groups fail to provide sufficient shutdown capability, but which will result in a very lengthy and costly process to remove the poison in order to restart the reactor.

Research Reactors that employ a Second Shutdown System have generally been designed from the outset with such a system implemented as an integral aspect of core design. Such implementations are generally limited to a heavy water dump (as with the OPAL reactor in Australia), or the injection of a soluble poison such as Boric acid or Gadolinium nitrate (as with the Egyptian reactor ETRR-2 and a number of Russian-designed research reactors). The SAFARI-1 core does not lend itself readily to such systems without a major redesign of the core, and implementing them without a major redesign, as seen in this project, reveals a large difference in the scale of effectiveness. The result is that a Second Shutdown “System” at SAFARI-1 needs to derive benefit from the cumulative effect of several different and redundant methods to effect short term and long term shut down.

There are a number of methods for reducing the reactivity in a reactor core with the objective of shutting down the fission reaction:

- By introducing a neutron absorber,
- By removing fuel,
- By changing the core geometry to a sub-critical geometry,
- By removing neutron reflecting material (e.g. Beryllium in the case of SAFARI-1) to increase neutron leakage from the core. Many reactors (but not SAFARI-1) use a heavy water reflector that can be drained away from the core.
- By reducing moderation – i.e. removing the moderator, reducing its density or increasing its temperature,
- By increasing fuel temperature.

The latter two methods assume, as is the case with SAFARI-1, that the core has a negative reactivity temperature coefficient for the moderator and the fuel respectively.

The safety function of a Second Shutdown System (SSS) needs to be carefully evaluated, a RELAP model analysed the Hot-spot cladding temperature and temperature at the onset of nucleate boiling for a step insertion of reactivity. However, the levels of redundancy and diversity of systems addressing the safety function, as described in this project, ensure that the automatically triggered systems comprising the “immediate” shutdown capability. It is therefore recommended that additional measures to meet the long-term requirements of the SSS. The neutronic feasibility for each proposal is given reasonable detail and the numerous engineering challenges in the proposed implementation be resolved before implementation can be effected.

4 Conclusion

A number of recommendations were identified by the safety reassessment feasibility investigations, including stabilisation of fresh fuel store, emergency water return, external plugin power, re-flooding nozzle, emergency control room, independent seismic trip, second shutdown system, reactor building reinforcement and updating emergency procedures.

Most of the recommendations have been taken to the implementation phase, the work stabilisation of fresh fuel store has advanced quite rapidly and the implementation demonstrated to be successful. The verification of the Re-flooding Nozzle proposed concepts by experimental mock-up is continuing unabated. The implementation of the seismic trip is expected to be listed in the end current financial year.

The emergency water return systems provision have been assessed and modifications to plant to effect the system are with the drawing office and the external portable pug in system effectively have been endorsed by the regulator and work to complete this project is continuing with full speed.

The second shutdown system and the reactor building reinforcement implementation work have not started and there is a huge possibility that the recommendations might not be implemented given the age of the reactor. The updating of the emergency procedures is a continuous effort and the work is coordinated in conjunction with the Necsca site.

5 References

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