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Experience, reviews, discussions

Operational Safety Experience of Ghana Research Reactor-1 and Its Impact on the Nuclear Power Program in Ghana

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Ghana has operated her miniature neutron source reactor with careful adherence to safety standards. Reactor's safety features have proven efficient and several efforts are underway at the Centre to ensure its safe operation. The ageing management policy of the Centre has usually been integrated into the existing schemes for ensuring safe practice. The periodic safety reviews that have also allowed for efficient safety analysis are also discussed. The establishment of the School of Nuclear and Allied Sciences by the Ghana Atomic Energy Commission in collaboration with the University of Ghana is facilitating training of the needed human resources for the operation of the facility as well as the planned nuclear power plant and maintenance of nuclear knowledge in the country.

1. Introduction

Ghana Research Reactor-1 (GHARR-1) is a Miniature Neutron Source Reactor (MNSR). GHARR–1 is a commercial MNS reactor similar to the Canadian SLOWPOKE in design (Akaho et al. 1995). It is a 30 kW tank-in-pool reactor, producing a peak or maximum thermal neutron flux in the core and its inner irradiation channels of 1×10^{12} ncm^{-2} s^{-1}. The reactor is designed to be compact and safe and it is used mainly for Research and Development in reactor and nuclear engineering, neutron activation analysis, production of short-lived radioisotopes, human resource development for Ghana's nuclear program and for education and training. It is cooled by natural convection and moderated with light water.

The GHARR-1 core currently employs 90.2 % enriched uranium-aluminium alloy admixed in aluminium matrix as fuel. A cross sectional view of the GHARR-1 core is shown below in Figure 1. GHARR-1 attained criticality on December 17, 1994 and has since been in operation (Maaku and Akaho 2002). With fifteen years of experience in operating GHARR-1, Ghana has expressed the interest in deploying a nuclear power plant to form part of her electricity grid to allow the country to achieve her set targets of economic growth (IAEA 2009b).

2. Institutions for assuring safety of GHARR-1

The Ghana Atomic Energy Act 204 of 1964 established the Ghana Atomic Energy Commission (GAEC) (GAEC 2006). The National Nuclear Research Institute (NNRI) is the Operating Organization of GHARR-1 and the Radiation

Protection Board (RPB) which was established by the legislative instrument LI 1559 of PNDC Law 308 is the Regulatory Body that has issued license for the operation of the reactor. Both the NNRI and RPB are provided Government of Ghana annual budgetary allocations for the operation and regulation of the reactor.

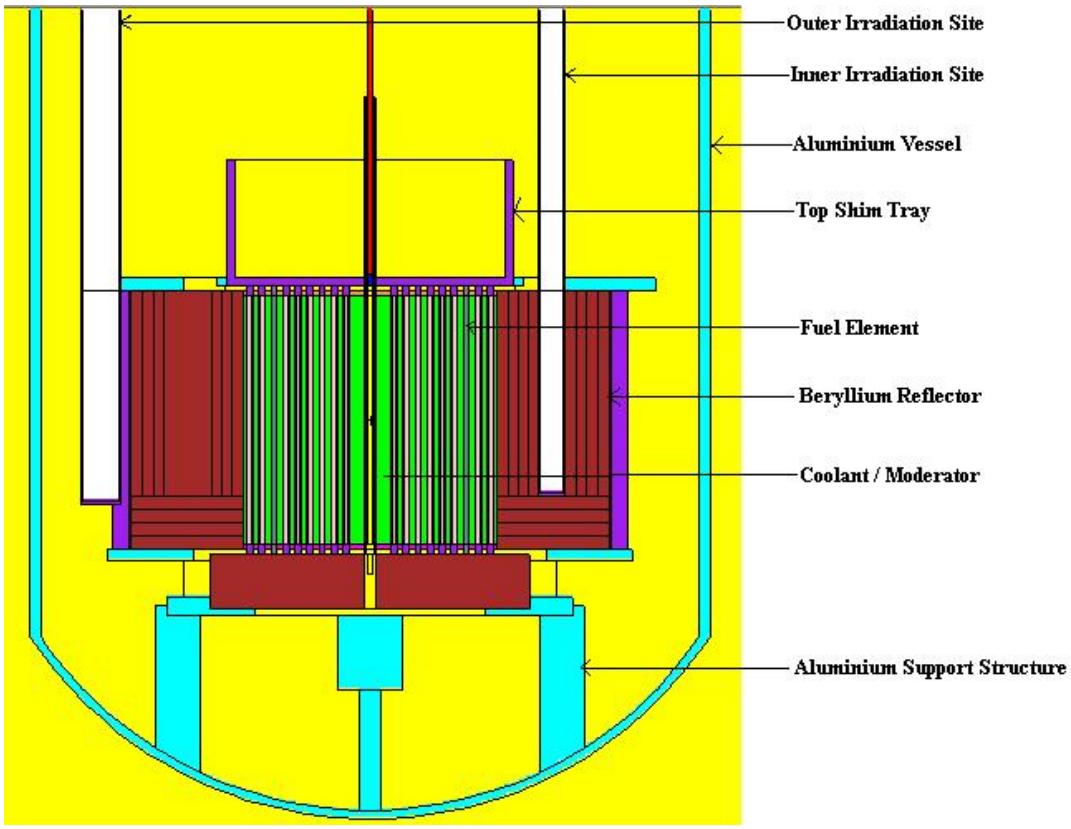

Fig. 1. Vertical cross section of GHARR-1 reactor (Ampomah-Amoako et al. 2009)

To ensure the safety of GHARR-1, the RPB performs a variety of activities, including the development and documentation of the licensing bases that specify plant design requirements and operation and maintenance (O&M) practices; the inspection and enforcement of license requirements; the performance of technical research and analysis; and the modification of regulatory requirements as needed. All of these activities are geared towards the safe operation and regulation of GHARR-1.

Although the RPB plays a central role in assuring safety of the reactor, the primary responsibility for the safe operation of GHARR-1 rests on NNRI, the licensee. NNRI is ultimately responsible for the design, operation, and maintenance of the reactor - not only to meet RPB requirements but to assure safety. To pool resources, share experiences, and coordinate efforts, NNRI collaborates with the IAEA to provide technical assistance for the safe operation of GHARR-1.

At the Operating Organization level, responsibilities that accompany the development and implementation of the Quality Assurance (QA) program are anchored on management of GHARR-1 providing means and support to achieve objectives; personnel performing work to achieve quality and evaluation of the effectiveness of management processes and work performance (Aboagye 2006).

In this vein, maintenance and periodic inspections are the responsibility of the maintenance Engineer of GHARR-1, who liaises with other sectional heads to accomplish tasks and appoint technicians to carry out the maintenance and inspection procedures under his supervision. Trained operators of the various systems are obliged to report all faults and outages of systems during operation, by completing the maintenance documentation forms for the respective systems. The verification of adherence to quality standards by means of periodic audits is performed by the QA Coordinator. Management is involved in non-conformance control and the determination of corrective actions to curtail the recurrence of non-conformance to quality standards.

3. Ageing management

The practices necessary to manage a nuclear reactor ageing are elaborate, beginning with design and analysis and extending to a variety of maintenance and research activities. The Microcomputer Closed Loop System has been replaced once and it currently has several capabilities

that were absent in the 1994 model. Some resistors, capacitors, bulbs, integrated circuits, fuses, dry cells, auto-synchronization, bearings, potentiometers and limit switches have been replaced to ensure efficient use of the facility. Two different sessions of beryllium plate addition have been performed to compensate for reactivity loss due to samarium poisoning and fuel burn up.

The strategies for ageing management based on the QA Program stems from identification and selection of components whose ageing has a high impact on safety performance (Novak and Podest 1987); review of design-basis safety margins, qualification testing, operating experience, experts' opinions, development of methods for surveillance, inspection, monitoring, and maintenance; and engineering studies including verification of inspection, surveillance, monitoring, and maintenance methods, *in-situ* examinations, collection of data from operating equipment, post-service examinations, tests of naturally-aged equipment, and cost-benefit analyses. Programs for periodic assessment based on broad operational data collection; programs for preventive maintenance; continuous monitoring of the reactor's components; feedback from incident analyses; individual and component qualification; personnel education and training; external control and quality assurance are the other avenues used to ensure safe operation of the reactor. The collection and evaluation of operational data are likewise receiving more attention. A computerized data collecting system is in place for operational records. Operational feedback is used to develop test specifications for electrical and other equipment. Corrosion of the cladding of the fuel element and other internal structural components in the reactor vessel is prevented by ensuring good water quality.

4. Periodic safety reviews

Safety reviews are performed regularly to ensure adherence to the regulations in use at the reactor facility. There is regular evaluation of operational activities by the staff of NNRI. The Reactor Safety Committee as well as the Radiation Safety Committee perform regular reviews of the safe practices at the Centre and provide their findings to the Director of NNRI for the necessary actions to be taken. RPB also conducts series of inspections to ascertain the level of adherence to their regulations. NNRI hosted an IAEA team of experts for an Integrated Safety Assessment of Research Reactors (INSARR) Mission as part of the Regional Workshop on the Review and Assessment of Research Reactor Safety Documents for African Countries hosted by the Institute in November 2008 (IAEA 2008). The Follow-up Mission was held from the 4th to 6th May, 2009 (IAEA 2009a). The visit afforded NNRI the opportunity to have a comprehensive review of both documents and activities that bother about safe practice.

5. Succession planning

GAEC in collaboration with the University of Ghana and assistance from the IAEA has established the Graduate School of Nuclear and Allied Sciences to train personnel for Ghana's nuclear practice and for the Africa Region. This School offers courses in Nuclear Engineering, Applied Nuclear Physics, Radiation Protection, among others. The students from this School are trained on practical approaches to solving problems. This kind of approach coupled with the support of both the Government and the IAEA can go a long way to prepare human resources to carry on with the operation of the facility as well as the future nuclear power program of the country.

6. Conclusions

The institutions established to operate and regulate GHARR-1 have striven to adhere to safety regulations and practices. The support received from the Government of Ghana and the IAEA has endeared us to achieve this feat. With the experience gathered through the operation of GHARR-1, it is evident that Ghana is on course to apply international standards to her nuclear power program to ensure its successful implementation.

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Patirtis, apžvalgos, diskusijos

Ganos eksperimentinio branduolinio reaktoriaus saugumas ir poveikis Ganos branduolinės energetikos programai

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Ganos miniatiūrinis neutronų reaktorius veikia laikantis visų saugos standartų. Reaktoriaus veikimo saugumas yra įrodytas ir periodiškai tikrinamas, be to imamasi papildomų priemonių didinti jo saugumą. Bendradarbiaujant Ganos atominės energetikos komisijai ir Ganos universitetui, įsteigta Branduolinės energetikos mokykla, kurioje garantuojama, kad bus užtikrintas atominių reaktorių priežiūros personalo poreikis, taip pat žinių apie atominę energetiką sklaida šalyje.

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