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Prospective Activities Outlined for Regulatory Approval in Ghana: Overview

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ABSTRACT

The Ghana Research Reactor-1 (GHARR-1) is one of Chinese's Miniature Neutron Source Reactor (MNSR) which was purchased under a tripartite agreement between Ghana, China and the IAEA. The reactor was installed in 1994 and has since been in operation without any incident. It has been used chiefly for Neutron Activation Analysis (NAA) and Training of students in the field of Nuclear Engineering. The GHARR-1 has been earmarked for the Conversion of Core from HEU to LEU which is in accordance with the GTRI program and other related and/or associated programs. Over the past few years the National Nuclear Research Institute (NNRI), the Operating Organization of the Research Reactor for the Ghana Atomic Energy Commission (GAEC), has undertaken various tasks in order to implement the replacement of the reactor core. After completion, of the neutronic calculations, results showed that that an LEU fuel of 12.5% enrichment was desirable. However, recent developments have shown that an LEU fuel with 13% enrichment will be fabricated by the manufacturers, which is captured in a fuel specification document sent to NNRI by the CIAE. It is therefore imperative that all neutronic and thermal hydraulic calculation be done again to help acquire regulatory approval. Furthermore, the radiation exposure to personnel involved in the conversion must be estimated to help convince our regulators. This paper outlines the processes and activities that will enable us meet regulatory requirements.

1. Introduction

Ghana Research Reactor-1 (GHARR-1) is a Miniature Neutron Source Reactor (MNSR). GHARR-1 is a commercial MNSR reactor similar to the Canadian SLOWPOKE in design [1]. 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 x 10^{12} n cm^2 s. 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 programme and for education and training.
It is cooled by natural convection and moderated with light water.
The GHARR-1 core employs 90.2% enriched uranium–aluminium alloy admixed in aluminium matrix as fuel. The diameter of the fuel meat is 4.3 mm and the thickness of the aluminium cladding material is 0.6 mm. The total length of the element is 248 mm.
The percentage of uranium in the U–Al dispersed in aluminium is 27.5% and the loading of U-235 in the core with 344 fuel elements is 990.72 g. In order to reduce the thermal resistance between fuel pellet and the cladding tube, the cladding is drawn to obtain mechanical close attachment between the cladding and the fuel meat. The clearance between pellet and end plug is 0.5 mm, which is allowed for thermal expansion of the pellets. To ensure fuel element stability in the core, the lower end of the fuel rod is designed to have a tapered structure which enables a self-lock fit between the fuel end and the lower grid plate and thus the fuel rods and dummy elements are tightly locked to the lower grid plate while its upper end is free in the lattice of the upper grid plate. The fuel cage consisting of 344 fuel pins, four tie and six dummy rods are concentrically arranged in 10 rings is located on a 50 mm thick bottom beryllium reflector of diameter 290 mm and is surrounded by a 100 mm thick metallic beryllium of height 238.5 mm [2]. The core is provided with a guide tube in the centre through which a central cadmium control rod with stainless steel clad moves to cover the full distance of the core of active height of 230 mm. The range of motion of the control rod is thus 0–230 mm. The bottom beryllium plate and the side beryllium annular form the inlet orifice and the supporting plate and the side beryllium annular form the outlet orifice. On top of the core is located an aluminium shim tray provided for housing beryllium reflector shims of regulated thickness required for adjusting or compensating the core excess reactivity due to fuel depletion and samarium poisoning. The regulated thickness refers to the required thickness of the reflector to compensate for reactivity loss due to fuel burn up and fission poisoning. The single control rod is used for regulation of power, compensation of reactivity and for reactor shutdown during normal and abnormal operations. The reactor core is located in the lower section of a sealed aluminium alloy vessel of diameter 0.6 m which is hanged on a frame across a stainless steel lined water pool of diameter 2.7 m and depth 6.5 m.
In the utilization of MNSR facilities, one very important parameter is the use of neutron fluxes. It might be noted that the neutron flux plays a very important role in neutron activation analysis, preparation of the radioisotopes and in the training and education exercises. A minimum of 10^9 n/cm^2 s neutron flux is required for activation analysis [3].In 2006, the IAEA put together all the MNSR Operating Countries to undertake a Coordinated Research Project (CRP) that will ascertain the feasibility of replacing the HEU fuel of Reactor with LEU. This CRP was successfully completed in March, 2012 after various meetings were held to discuss results and prepare the way forward. Subsequently, a Working Group was formed to monitor the progress of the various MNSRs Conversion Activities and to share lessons learnt with each other.

2. Calculations

An initial LEU fuel enrichment was agreed upon based on calculations from CRP [4]. Due to the recent change in the enrichment of from 12.5% to 13%, neutronic and thermal hydraulic computations will have to be done in order to meet regulatory requirements. Parameters like the core loading, shutdown margin, beryllium shim worth, reactivity feedback coefficient, control rod worth (both integral and differential), generation time etc. are all neutronic parameters that must be recomputed to meet requirements.

The spent nuclear fuel inventory for the GHARR-1 fuel has to be estimated the whole operational history of the core. The inventory will then be used in a neutronic code to estimate k_{eff}. The source term for the SNF has to be estimated. This is important because it will help us estimate the dose to be received by personnel during removal of the core.it will also help to ascertain that the SNF is sub critical.

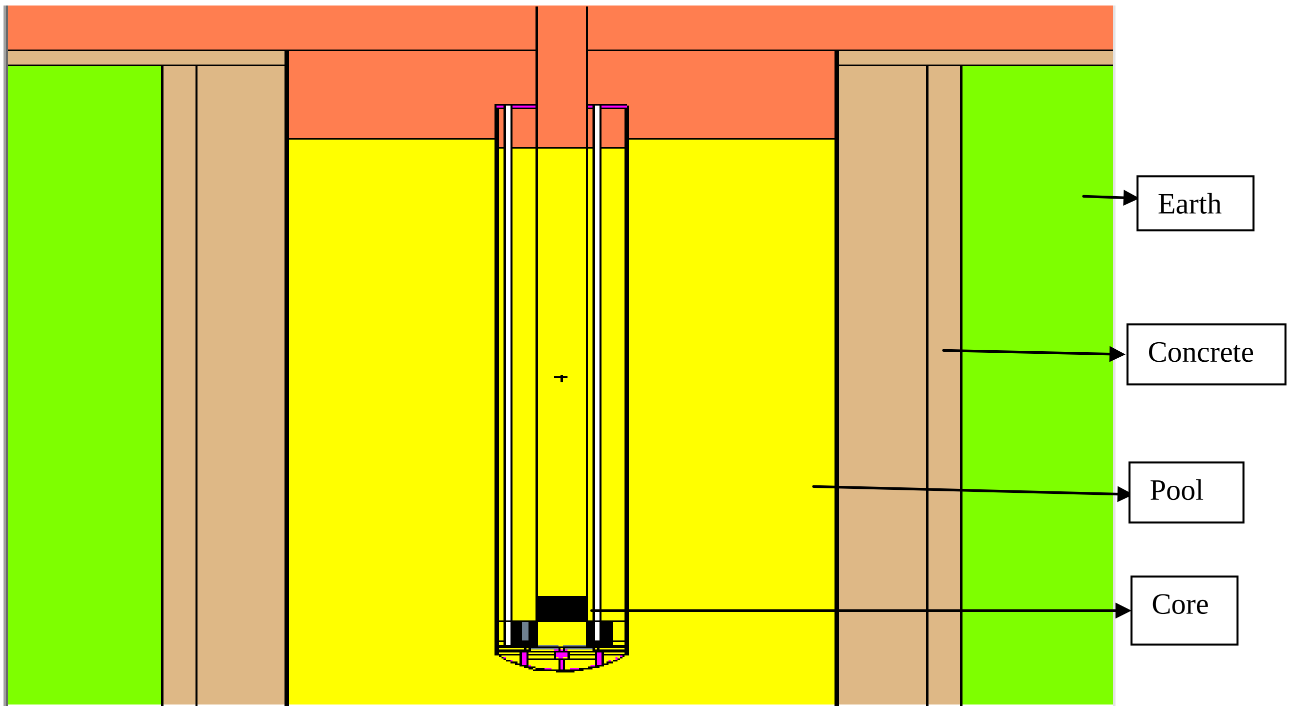

FIG 1: X-Y CROSS SECTIONAL VIEW OF THE HEU CORE BEINGLIFTED JUST ABOVE THE ANNULAR BERRYLIUM

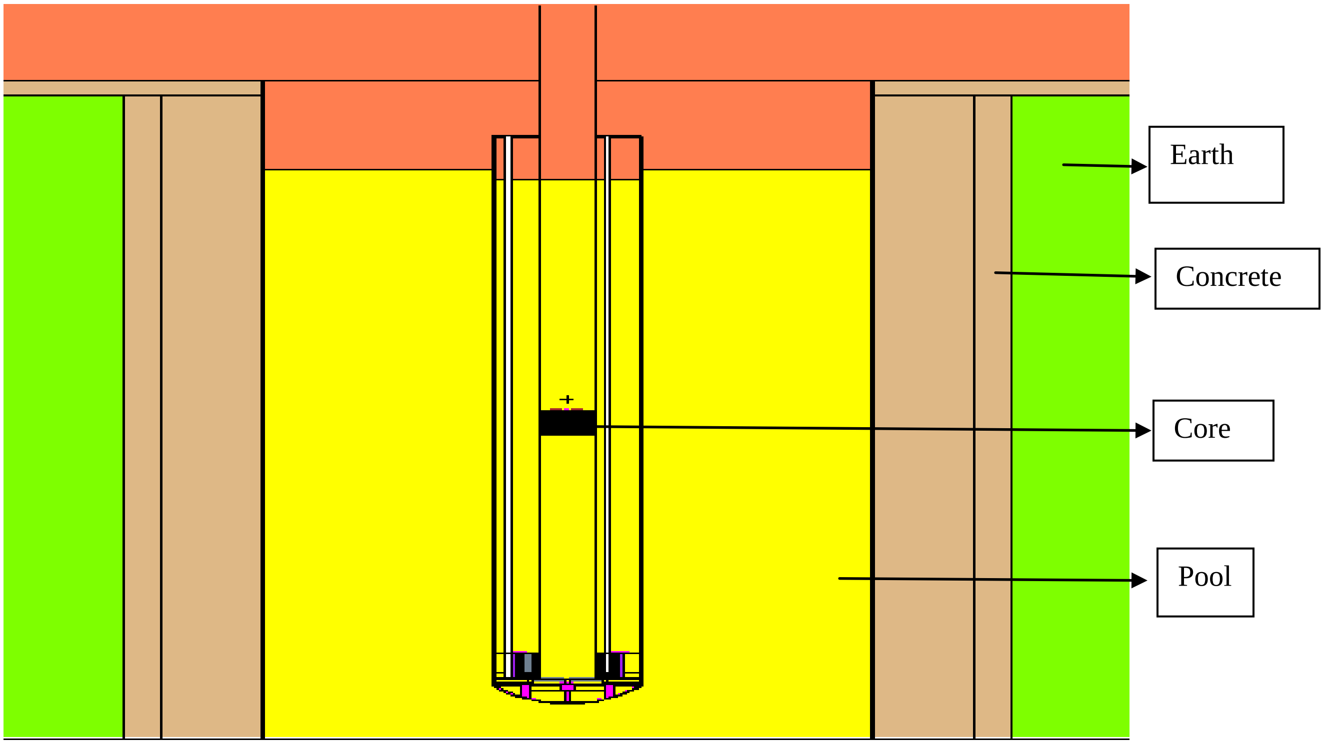

FIG 2: X-Y CROSS SECTIONAL VIEW OF THE HEU CORE BEING LIFTED MID WAY THROUGH ON ITS WAY OUT OF THE VESSEL

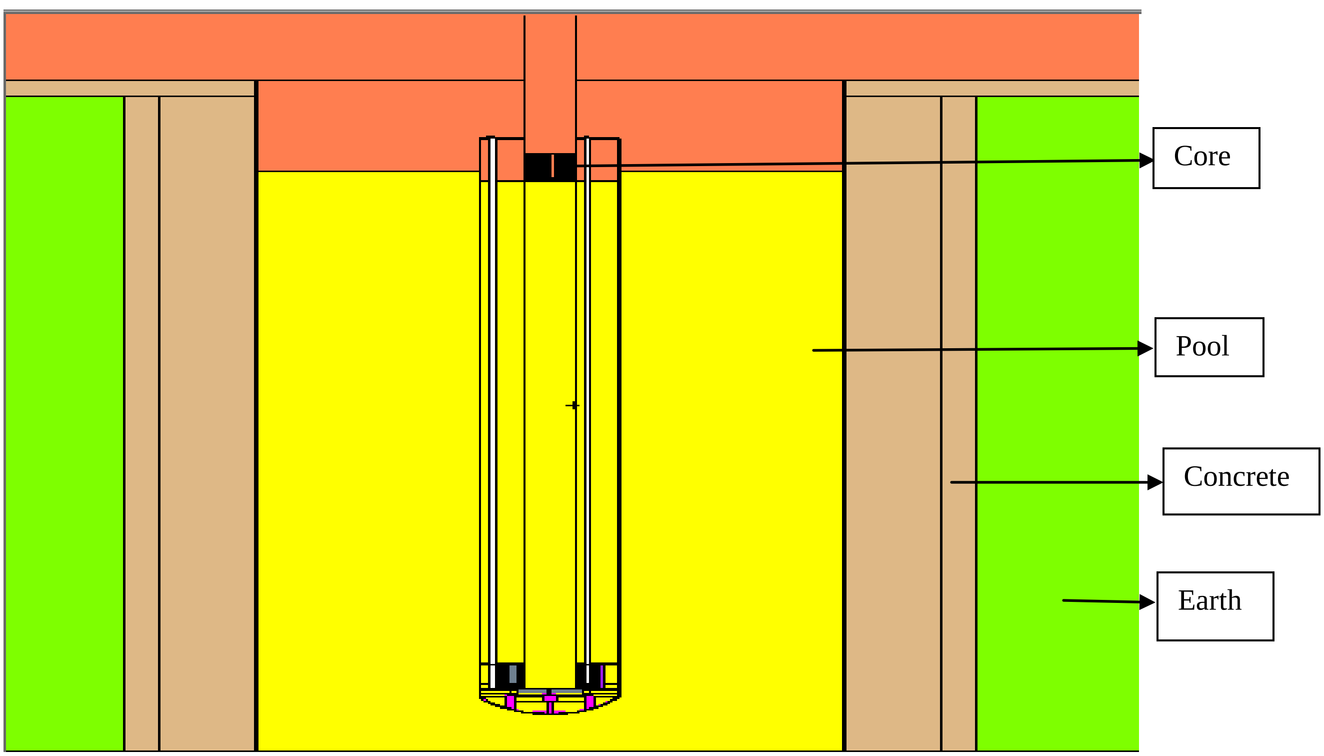

FIG 3: X-Y CROSS SECTIONAL VIEW OF THE HEU CORE BEING LIFTED JUST ABOVE THE

ANNULAR SURFACE OF THE REACTOR WATER

3. Documentation

A project management team has been established with the core mandate of ensuring successful planning and execution of the Reactor Core Conversion Activities. Obtaining a license to operate the new LEU core is a very important part of the overall process. A key requirement is to present all necessary documentation on the various procedures involved in the core conversion activities for their approval. Valuable documents include

i. Procedures for offloading SNF: There is a draft copy of this document already in place. We are waiting for the procedures from SOSNY so that we can harmonize the two documents to fit our situation.
ii. Procedure for loading new LEU core: The project management team also has a draft document in place.
iii. Procedures for Zero Power Test: This is yet to be drafted and the team is working on it.
iv. Core conversion Safety Analysis Report: This document has been completed and sent to the Regulatory body for approval. We were asked to make some amendments and provide answers to their concerns. This has been done and sent back to the regulatory body.
v. Radiation Protection procedure for removal: Radiation protection group is currently working on this document.
vi. Emergency procedure: Physical protection group currently working on document that will spell out processes to follow when emergencies arise.
vii. Fire procedure: Safety group currently working on document that will address fire
viii. Safety and safeguard procedure: Safety group currently working on document that will encompass all activities with respect to safety and safeguards.

4. Licensing

The Radiation Protection Board (RPB) has been notified of the Core Conversion Program and they are preparing for the task ahead in terms of Licensing. At various legs of the core conversion program, different licenses must be obtained. Import license should be acquired for the incoming LEU fuel whilst export license should be acquired for the SNF that will be shipped off to China. A series of meetings must be convened with the regulators to determine the requirements for obtaining these licenses. Training courses, should be organized for staff of the regulatory authority to give them the requisite experience and knowledge to handle the licensing process (it is the first time they are encountering a challenge on core conversion)

5. Challenges

The current energy crises in Ghana makes it extremely stressful to compute all the parameters (neutronic, thermal hydraulic, dose etc.) to meet set targets. Bureaucratic processes in the commission also slows down the pace of work and hinders progress. It is clear that core conversion thrives on a strong collaboration. However, since some of the processes, for example, the design and use of the transfer cask for the removal of SNF is done by other partners, the submission of the procedure for this activity, will depend on how fast the other party submits its procedures for scrutiny and onward transmission to the regulatory body. Any delay by the collaborators, will in turn cause a delay in the approval and acquisition of a license.

6. Conclusion

The importance of the regulatory body in the smooth completion of the core conversion cannot be over emphasized. Plans are far advanced to meet the requirement of the regulatory body to facilitate the fast and safe conversion of GHAAR-1. Effective communication and efficiency on the path of collaborators should be encouraged in order to reduce the challenges that currently exist.

7. Acknowledgement

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8. References

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