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Role of the Regulatory Body in Ghana's MNSR Conversion from HEU to LEU

R. G. Abrefah[1]*, E. Ampomah-Amoako[1], M. Asamoah, J. Ayivor[1], E. Mensimah[1], A. E. Mensah[1], K. Appiah[1], L. Ameh[1], M. Annor-Nyarko[1], A. Y. Kyei[1], S. K. Dzide[1], D. Sika-Boafo[1], G. Emi-Reynolds[1]

[1] Nuclear Regulatory Authority, Ghana, P.O. Box AE 50, Atomic Energy, Kwabenya, Accra-Ghana

ABSTRACT

Ghana has been operating her Miniature Neutron Source Reactor (MNSR), Ghana Research Reactor-1 (GHARR-1) since March 1995. In view of the international efforts at reducing the use of high-enriched uranium fuel in civilian reactors, the facility's conversion was performed in 2016 and 2017. The regulatory oversight of nuclear safety was performed initially by the Radiation Protection Board and finally by the Nuclear Regulatory Authority which was established in 2015 by Act 895. The assistance received from the International Atomic Energy Agency in issuing requirements for the conversion are presented. The safety submittals received and the review process are discussed along with lessons learnt from the regulatory oversight. The licensing process is also presented to demonstrate the independence of the regulatory process.

Introduction

Ghana has been operating her Miniature Neutron Source Reactor (MNSR), Ghana Research Reactor-1 (GHARR-1) since March 1995 [1]. Figure 1 below presents a schematic view of the reactor. In view of the international efforts at reducing the use of high-enriched uranium fuel in civilian reactors, the facility's conversion was performed in 2016 and 2017. The regulatory oversight of nuclear safety was performed initially by the Radiation Protection Board (RPB) and finally by the Nuclear Regulatory Authority (NRA). The Authorised Person of the reactor is Ghana Atomic Energy Commission (GAEC).

The Nuclear Regulatory Authority Act, 2015 (Act 895) established the NRA. The NRA provides for the regulation and management of activities and practices for the peaceful use of nuclear material or energy, radioactive material or radiation; to provide for the protection of persons and the environment against the harmful effects of radiation hazards; to ensure the effective implementation of Ghana's international obligations and for related matters.

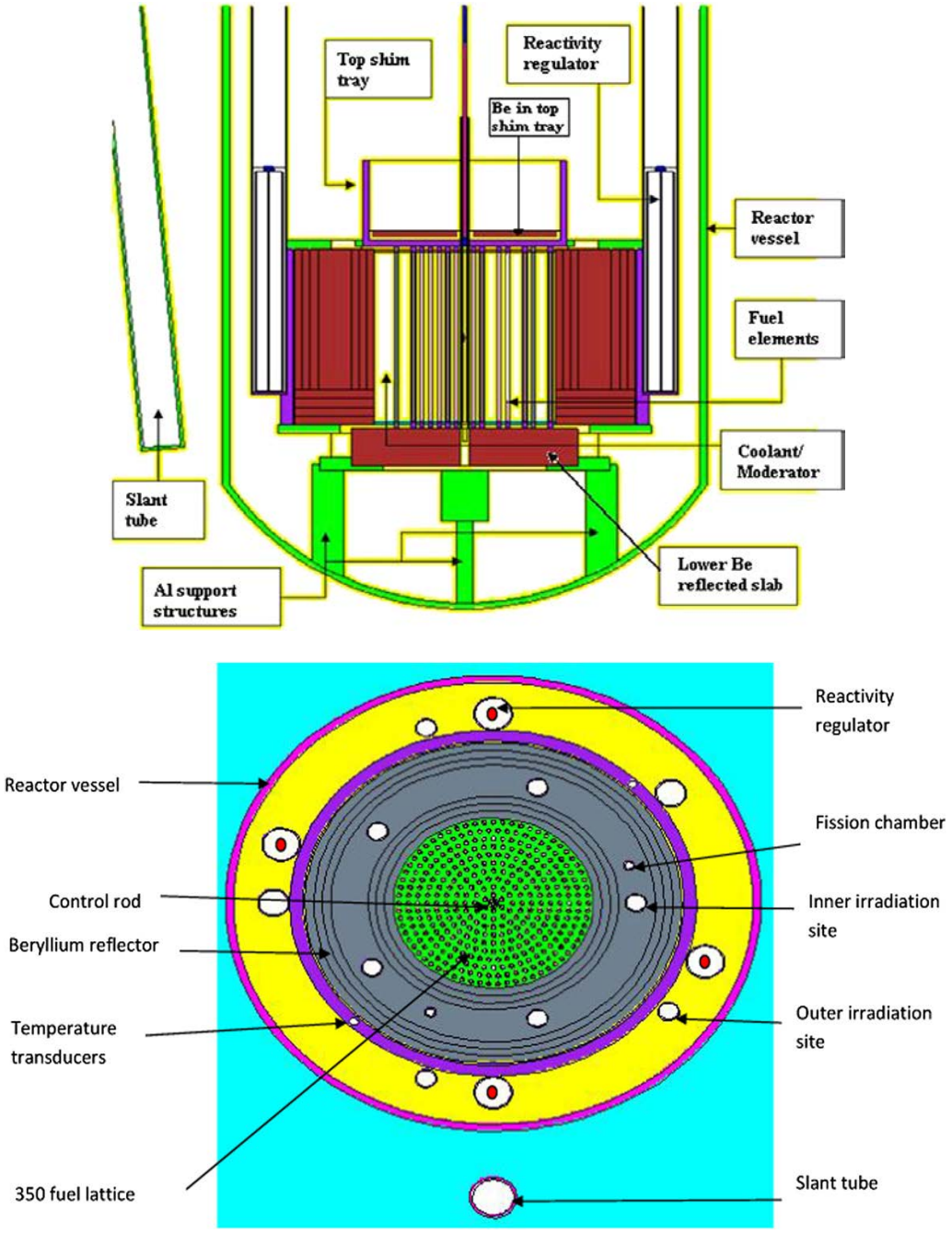

Figure 1: Cross sectional view of GHARR-1[1]

Prior to the formation of the NRA, the Radiation Protection Board (RPB) established in 1993 by PNDC Law 308 with its mandate prescribed in LI 1559 performed the regulatory oversight of the initial stages of the conversion.

Regulatory requirements were developed with assistance from the Agency through an Expert Mission. Timelines were assigned to the submittals associated with the requirements and communicated to the Authorised Person.

The Core Conversion Safety Analysis Report was reviewed by staff of the RPB who provided request for additional information (RAIs) to the Authorised Person.

The implementation of the Core Conversion was held in four phases: Core Removal [2], Core Packaging [3], Core Loading [4] and HEU Package Transport Phases [5].

The irradiated HEU fuel was to be stored for forty (40) days after which it was to be transported to China. Unfortunately the required permissions could not be obtained from the Chinese counterparts which altered the schedule as discussed below. The transport equipment for the fuel was received in Ghana on schedule. The irradiated HEU fuel was transferred from the Interim Transfer Cask (ITC) into the licensed TUK/MNSR-C Cask which was detached from its trailer in October 2016.

The activities of the LEU Core Loading Phase was executed in five (5) sections, namely Preparation Works; Criticality Experiments; Reactivity Adjustments and Final Reactivity determination; Reactor Power Calibration; and Commissioning.

The HEU Package Transport Phase was supervised by NRA in collaboration with the National Security Council with active involvement of the Nuclear Security Committee on 26th and 27th August 2017.

Regulatory Framework

The Radiation Protection Board (RPB) was established in 1993 by PNDC Law 308 as the National Competent Authority for authorization and inspection of practices using radiation sources and radioactive materials in Ghana.

Act 588 of 2000 which superseded Act 204 provided the basis of establishing research institutes to perform the functions including: to make proposals to the Government of Ghana for legislation in the field of nuclear radiation and waste management and to advise the Government on questions relating to energy, science and technology.

The Ghana Atomic Energy Commission 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 was the Regulatory Body that has issued license for the operation of the reactor

prior to formation of the Nuclear Regulatory Authority (NRA).

The organogram of RPB is presented in Figure 2 below.

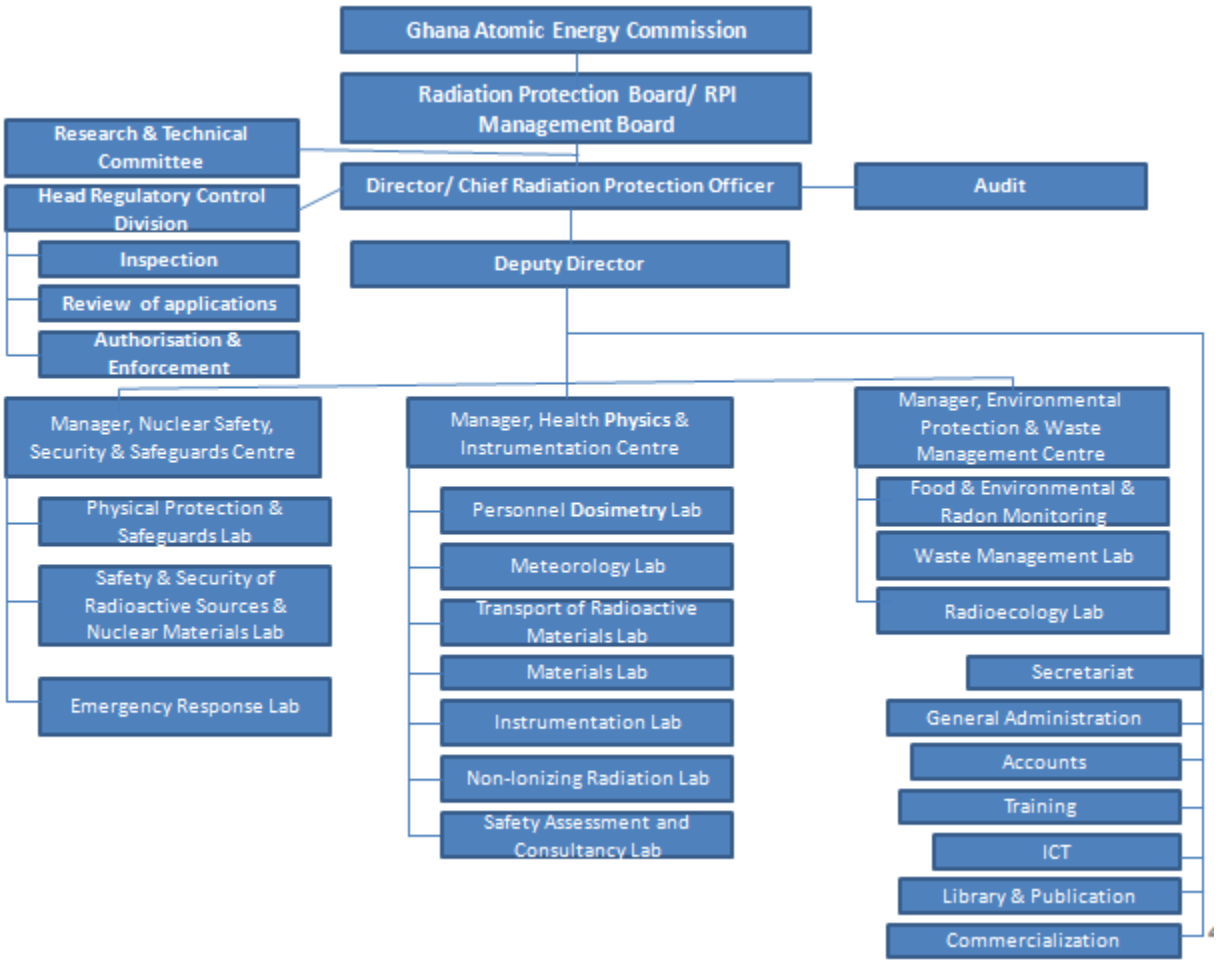

Figure 2: Organogram of Radiation Protection Board (Former Regulatory Body)

Staff from Ghana Atomic Energy Commission (GAEC) were transferred to form foundation staff of NRA in January 2016.

The objectives of the Authority are to: ensure that radiation and nuclear energy is used by only persons authorised under the Act 895 for peaceful purposes; provide protection of persons and the environment against the harmful effects of radiation hazards; and to pursue and ensure strict compliance with Act 895 and Regulations. The Authority is organised as shown in Figure 3 below.

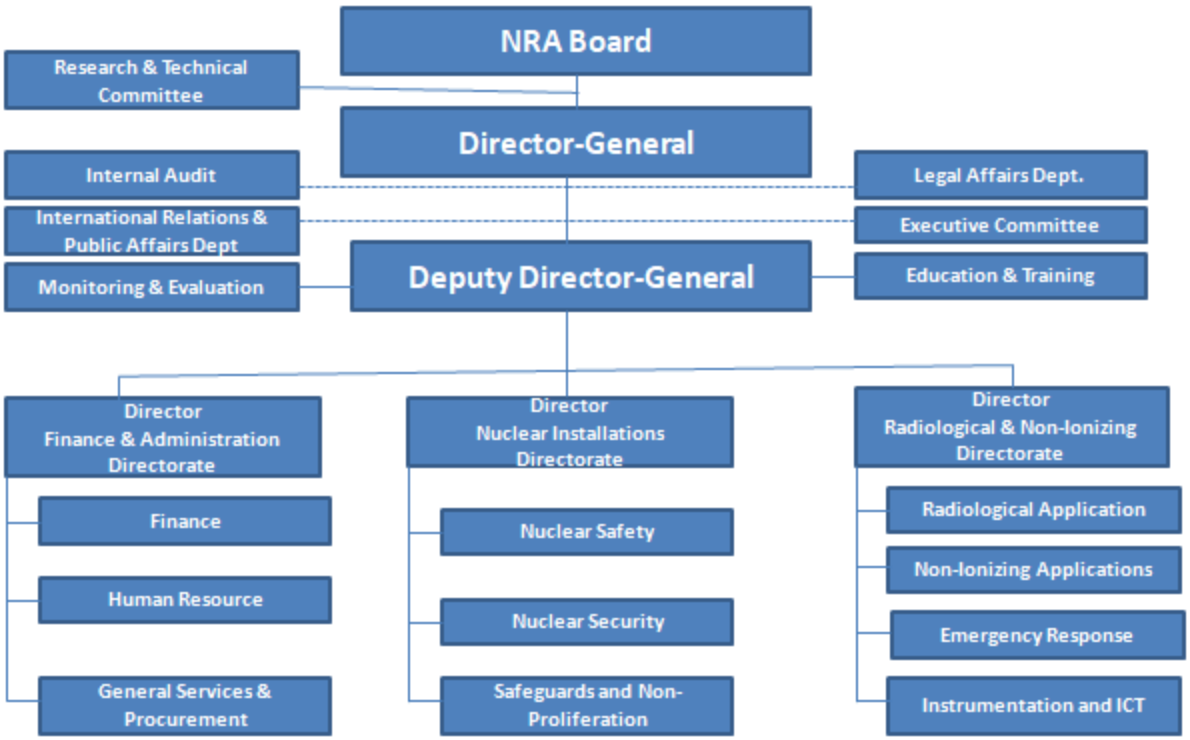

Figure 3: Organogram of Nuclear Regulatory Authority

The Board of NRA initiates policies for the development of the Authority, ensures the proper management of the resources of the Authority, ensures the implementation of the functions conferred on the Authority under Act 895 and any other enactments and meets at least once every three months.

The Research & Technical Committee of NRA reviews policies, criteria, guidelines, procedures and other related matters of the Authority; reviews the licensing and certification requirements for technical support services and consultancies; reviews and recommends for the NRA Board's approval reports to be sent to International Atomic Energy Agency. The Committee holds sufficient scheduled meetings in order to discharge its duties and meets at least four (4) times a year, or more frequently as circumstances dictate.

The Finance Committee of NRA looks at the financial position of the Authority at each time and suggests avenues of improving upon income generating activities of the Authority; reviews the financial statement of the Authority for each year and submits its comments and recommendations to the Authority for the necessary action to be taken; reviews investment instruments for financial sustainability of the operations of the Authority for approval by the NRA Board. The Committee meets at least thrice in a year.

The Executive Committee assists the Director-General in the day to day administration of the affairs of the Authority as set out in Section 16 of Act 895. The Committee recommends policy

criteria, guidelines, procedures and other related matters of the Authority for review by Research & Technical Committee; recommends the licensing and certification requirements for technical support services and consultancies; recommends for approval reports to be sent to the International Atomic Energy Agency, including reports on Ghana's obligations under the Joint Convention, Convention on Nuclear Safety, Safeguards and its Additional Protocol, among others. The Committee holds sufficient scheduled meetings in order to discharge its duties.

The Nuclear Regulations Guidance Committee has been established to undertake review of regulations development process ranging from outline to content before onward submission to Research & Technical Committee of the NRA Board.

The three Directorates are headed by Directors and the Departments have Heads of Departments. Regulations are drafted at the Directorates, reviewed by Nuclear Regulations Guidance Committee, followed by review from Research & Technical Committee and the Board.

Stakeholders are consulted and involved in the development of the regulations through Workshops, Public Meetings and involvement in Committees. The regulations so developed are forwarded to Parliament for Gazetting.

The requirements utilized for the regulatory oversight of the core conversion hinged on the International Atomic Energy Agency (IAEA) Safety Standards and three additional requirements issued for Minimum Qualifications required of Personnel for the Conversion Activity [6], Equipment Qualification and Licensing and Air Flight Requirements [7]. The Authority received assistance from the IAEA in setting out the regulatory requirements and documents to be submitted to enable effective regulatory oversight of the Core Conversion. The Agency offered to provide additional assistance if that was needed. Participation of staff in various activities of the Agency enabled effective implementation of our mandate for the Conversion.

Regulatory Reviews

The Safety Submittals from the Authorized Person were Core Conversion Safety Analysis Report, Core Displacement Safety Analysis Report, Procedure and Loading of HEU Core into SKODA Cask, Core Loading and Initial Test Procedures, Emergency Preparedness, Fire Safety Plan, Radiation Protection Plan, Transport Preparation Plan, Report on Effects of 0.5 % Increment in Enrichment of Proposed LEU Fuel, Refurbishment of Instrumentation and Control System, Summary Report on Zero Power Test, LEU Loading Procedure, Critical Experiment, On-Site Zero Power Experiment, Power Rising Experiment, Full Power Experiment, Environment Monitoring Experiment, Safety Performance Characteristics Experiments, Reactor Pool and Vessel Inspection Report, Report on Replacement of Crane; and Safety Analysis of ES-3100, Interim Transfer and TUK/MNSR-C Casks [8, 9].

Teams of qualified staff were constituted to conduct reviews of each of the submittals. The Teams utilized International Atomic Energy Agency (IAEA) Safety Standards as basis for the review of the submittals. The number of personnel in each Team corresponded with the content and volume

of the submittal received. The average size of a Team was three (3) staff of the Authority.

Requests for Additional Information were communicated to the Authorised Person and responses were received to enable effective review of the submittals against the IAEA Safety Standards and the three additional requirements issued to the Authorised Person.

Authorisations were only granted after regulatory requirements were met for the activity to be authorised. Activities which could be separated from the mainstream conversion were deferred to enable effective implementation of the Conversion Exercise.

Facility Acceptance Tests

Staff of the Authority participated in Facility Acceptance Tests (FAT) for Interim Transfer Cask (ITC) and Underwater Cameras conducted in Russia at SOSNY in Dimitrovgrad and JS Diakont in St. Petersburg [10].

During FAT on the ITC, activities of the SOSNY Research and Development Company were introduced after which the functioning of the cask was presented. The Interim Transfer Cask, frame to install the interim transfer cask, adapter pintle, guard, guard support, freight track, mockup core, guide tube, centering device, trays and technical documentation were inspected. A demonstration of the steps in operating the transfer cask and its associated components was observed. The control systems for the ITC were also tested. A mockup SKODA MNSR cask was used to demonstrate the manner in which the interim storage cask will be used along with the SKODA MNSR cask. The Inspectors endorsed the Acceptance and Facility Acceptance Tests Reports along with seven officers of SOSNY. The Data Sheets attached to the documents were in Russian language and so the vendors had to translate them into English language. Some chapters that were not properly assigned to the customer were resolved. Graphic images were included in the item certificates.

During the Underwater Camera FAT, the functioning of the STS-40M Visual Inspection System including D40M TV camera, housing, MT-40S camera module, set of plug-in parts, L40-17S lens, L40-6S lens, frontal light head H40-01S, frontal light head H40-03S, radial light head H40-05S, rotation unit R40S, K-SK40SR-38 camera cable, A-40A camera control unit with mains cable, PU-U multiple-purpose control panel with connecting cable, laptop with set of TopVision software equipped, set of spare parts, tools and accessories and set of operation documentation were inspected. The Proton Camera System including a TV transmitting device HD98, camera control unit A-98 with mains cable, camera cable K-SK98-30, PU-U multiple-purpose control panel with connecting cable, video monitor LCD 24" with mains cable, set of spare parts, tools and accessories and set of operation documentation were inspected.

Inspections and Meetings with Authorised Person

The Authority conducted inspections to ascertain the analysis captured in the submittals to allow for clarity and to ensure that preparations were in line with the reviewed procedures and assessments. Staff of the Authority were assigned to various verification activities to assist in regulatory decision making.

Regulatory inspectors supervised the implementation of the various phases of the Conversion exercise.

Meetings were held with the Authorised Person to discuss requirements, additional information requested and find common grounds for ensuring effective implementation of the conversion.

The Authority participated in some of the Consultancy Meetings and Expert Missions facilitated by the IAEA for the Conversion activities [11, 12, 13, 14].

Authorization of Activities

The authorizations issued for the Core Conversion included permits, certifications, and licenses with relevant hold points and licensing conditions. Each of these was characterised by submission of required documents to enable regulatory review and assessment. The permits given for the Core Conversion were Import Permits for ES3100, TUK/MNSR-C with SKODA cask, ITC, LEU fuel; export permits for TUK/MNSR-C, HEU fuel, ES3100; and Storage of HEU, LEU and Transport permits. Certificates were given for ES3100, TUK/MNSR-C with SKODA cask, ITC, Environmental Radiation and Certificate of Compliance.

The licenses issued for the Core Conversion were to Remove and Store HEU Core; LEU Loading; Beryllium Shim Storage Cask and currently licensing the Training Centre.

Oversight during Implementation of Activities

During the Core Removal Phase, regulatory inspectors were assigned to supervise the conduct of activities associated with the Core Removal and storage in the Interim Storage Cask. The inspectors observed the unpacking of equipment for the Dry Run, assembling and mounting on the Training Facility and the reactor building entrance by the Experts and staff of GAEC.

A theoretical and practical training was held for staff of GAEC who were going to be involved in the core removal exercise from 22nd to 24th August 2016. A demonstration of the core removal process was conducted for staff of NRA in the afternoon of 24th August 2016. Security personnel on duty during the dry run were allowed to have a view of the process by which the core was going to be removed from the reactor vessel.

Preparations were properly carried out to enable effective execution of the exercise.

The various settings for instrumentation systems were properly laid out by the evening of Saturday, 27th August 2016. The Interim Storage Cask (ITC) which was certified by NRA was placed on the top of the reactor vessel in readiness for the removal of the core.

At 7:18 am on Sunday, 28th August 2016, a briefing was held for all participants of the Core Removal Exercise at the Entrance of the GHARR-1 Facility. The Project Management Team provided the Emergency Procedures which could be initiated by a voice call or an alarm. Some restrictions were instituted for members of the operating staff. Activities were expected to be straight forward at the onset. The Pintle could not correspond with the grapple to allow for opening and then later closure. The ITC was removed at 9:25 am to allow for configuring by SOSNY staff.

At 10:28 am, the grapple was ready to be installed into ITC and at 10:45 am, the ITC was placed on the vessel again.

The core was out of the vessel at 11:00 am. The radioactivity measurements confirmed they were below regulatory limits for the core conversion.

A crane to lift the package from the entrance of the Reactor Hall to the ground arrived at 3 pm and the package was moved at 3:20 pm and arrived at the Storage Facility at 3:30 pm when the ITC was offloaded.

In the HEU Core Packaging Phase, a forklift was used to transport the ITC from the Licensed Storage Facility to the Working Platform. The upper segment of the TUK/MNSR-C Cask was lifted with a crane. The vacuumed SKODA cask was placed into the lower portion of the TUK/MNSR-C Cask after which the upper segment was installed to cover the SKODA Cask. A tarpaulin was used to cover the package. The Packaging was carried out on the Working Platform adjacent the Training Centre opposite the entrance to the GHARR-1 Centre. The fresh HEU pins which were extra to the 344 fuel pins in the core were retrieved from its storage. The SKODA Cask was positioned on a tarpaulin on the Working Platform after which the fresh pins were loaded into one of the three baskets of the Cask. Shock absorbers were installed for the irradiated fuel after which the fuel was loaded into one of the two remaining baskets of the SKODA Cask. The SKODA Cask was covered followed by a helium test to ensure effective drying.

During the LEU Core Loading Phase, three hundred and thirty-five (335) LEU fuel pins were arranged into the fuel cage forming the reactor core. The Core Basket was prepared and lowered into the vessel with a short procedure using a Chinese-designed setup. First criticality of the fresh core was achieved at 1:23 p.m. on 13 July 2017. Observation of reactivity control tests and power calibration tests was carried out. Reactivity experiments were carried out to adjust it to required levels.

During the HEU Package Transport Phase, the Nuclear Regulatory Authority (NRA) verified submittals for safety, security and safeguards to ensure compliance of the Authorised Person with

national and international requirements for the transport of radioactive materials. The package was clearly labeled as a Class 7 good. The crane, trailer and backup trucks were inspected by the staff of NRA to confirm their readiness for the exercise prior to the movement.

The Customs Division of Ghana Revenue Authority (GRA) verified documentations and cleared the package prior to departure from GAEC Reactor Site. NRA collaborated with National Security Council in securing the transport of the Package.

The Authorised Person is required to submit a revised Safety Analysis Report, among other submittals in Ghana.

Conclusion

The regulatory oversight of the Core Conversion was provided by the Radiation Protection Board (RPB) and Nuclear Regulatory Authority (NRA) to ensure effective implementation of the Conversion Exercise. Facility Acceptance Tests have been found to be very effective in ensuring quality control of items used for the Conversion activities. Submittals were received from the Authorised Person, Ghana Atomic Energy Commission (GAEC) and reviewed by staff of the Authority based on IAEA Safety Standards. The Conversion has assisted in revealing some of the anticipated challenges for oversight activities associated with other nuclear installations such as the planned nuclear power programme in Ghana.

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