The status of HEU to LEU core conversion activities at the Jamaica SLOWPOKE

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Abstract

The SLOWPOKE reactor in Jamaica has been operated by the International Centre for Environmental and Nuclear Sciences, University of the West Indies since 1984, mainly for the purpose of Neutron Activation Analysis. The HEU core with current utilization has another 14 years of operation, before the addition of a large beryllium annulus would be required to further extend the life-time by 15 years.

However, in keeping with the spirit of the Reduced Enrichment for Research and Test Reactors (RERTR) program, the decision was taken in 2003 to convert the core from HEU to LEU, inline with those at the École Polytechnic and RMC SLOWPOKE facilities. This paper reports on the current status of the conversion activities, including key fuel manufacture and regulatory issues, which have seen substantial progress during the last year. A timetable for the complete process is given, and provided that the fuel fabrication can be completed in the estimated 18 months, the core conversion should be accomplished by the end of 2014.

1. Introduction

The SLOWPOKE reactor in Jamaica has been operated by the International Centre for Environmental and Nuclear Sciences (ICENS), University of the West Indies (UWI) since 1984. The main purpose of the reactor is Neutron Activation Analysis applied to environmental / health-related studies, and mineral exploration in Jamaica. In addition ICENS has cooperated with the International Atomic Energy Agency (IAEA) in the establishment of the Caribbean Research Reactor Coalition (CRRC) [1] with reactors in Colombia and Mexico, to increase regional access to research reactor services and nuclear-related education and training.

The high enrichment uranium (HEU) core with current utilization has another 14 years of operation, before the addition of a large beryllium annulus would be required to further extend the life-time by 15 years. However, in keeping with the spirit of the Reduced Enrichment for Research and Test Reactors (RERTR) program, and the move by the international community to eliminate the civilian use of HEU, the decision was taken in 2003 to look into possibility of converting the core to low enrichment uranium (LEU). In 2009, a formal request was made via the IAEA to the Global Threat Reduction Initiative (GTRI) and the Reduced Enrichment for Research and Test Reactors (RERTR) program to help fund the conversion of the reactor, and take back the spent fuel.

2. HEU Core

The ICENS SLOWPOKE core is fueled with ~ 1 kilogram of U.S. origin HEU, and has operated on average for 1300 hours per year at 10kW. The current core burn up is calculated to be approximately 51% of its total lifetime (Fig 1) with the present core configuration, and under current utilization patterns, has another 14 years of operation, before the addition of a large beryllium annulus would be required to further extend the life-time.

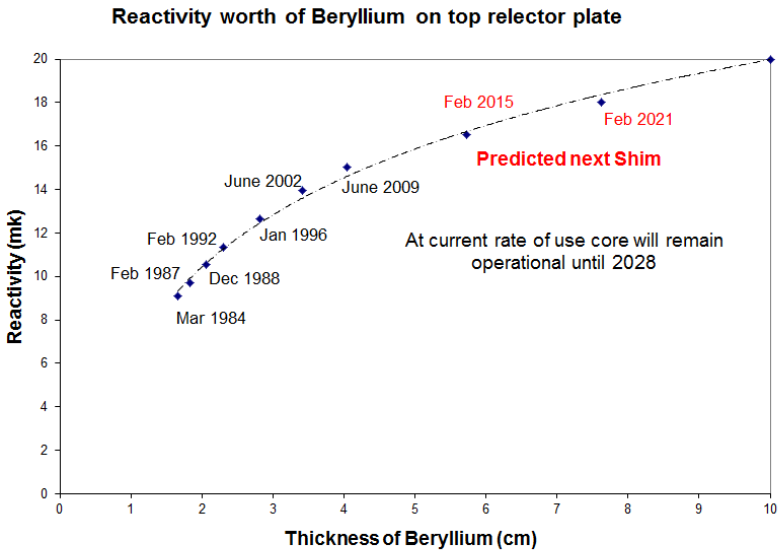

Fig 1, Reactivity worth of Beryllium on top reflector plate.

2.1 Estimated Fission Product Activity

The fission product activity of the used fuel has been calculated using the AECL method based on a SLOWPOKE reactor which was operated for 5 years at a neutron flux of 1 x 10^{11} n.cm^{-2}s^{-1} (2kW), then 10 hours at a neutron flux of 1 x 10^{12} n.cm^{-2}s^{-1} (20 kW) [2]. The calculated activity 30 days after shutdown was 23 TBq. Based on a maximum usage for the Jamaica SLOWPOKE of 4 hours per day 5 days per week at an average flux of 4.95 x 10^{12} n.cm^{-2}s^{-1} (average over the last 29 years), the 5 years average continuous flux would be 0.57 x 10^{11} n.cm^{-2}s^{-1} (1.1 kW). Considering maximum usage for the next 5 years, the expected activity of the core 30 days after shutdown should not exceed 13 TBq. Previous experience at the École Polytechnic SLOWPOKE has shown this calculation to be reasonably accurate (~18 TBq) [3], and that a one month cooling period is sufficient before the conversion process can take place. These estimates are to be verified with new models being developed in conjunction with Argonne National Laboratories (ANL).

2.2 LEU Fuel composition

Based upon the operational success of the AECL manufactured LEU cores, the ICENS SLOWPOKE will utilize fuel of identical composition and dimensions. Discussions are taking place between AECL and the Y-12 National Security Complex and it is expected that contracts will be drawn up shortly for AECL to manufacture the fuel and fuel cage, and Y-12 to supply the UO_2 ceramic powder and quality control. Neutronic and thermal-hydraulic models for the HEU and LEU cores will be developed in collaboration with ANL using the MCNP 5 [4] code and latest nuclear data libraries, to support the conversion safety analyses.

2.3 Facility Upgrades

In June of 2011, an independent facility review was carried out with the objective of evaluating the adequacy of the reactor site and facilities to support the LEU conversion planning and preparation activities. The resulting report [5] identified no major issues to prevent or delay proceeding with the conversion project. It recommended among other things that the planned replacement of the analog control system with a digital one, be carried out prior to the core conversion. The system being reviewed is a digital control and instrumentation system developed specifically for the SLOWPOKE-II reactor (SIRCIS) [6], which was commissioned at the Royal Military College (RMC) reactor in June 2001. Discussions have begun with the manufacturer to resolve long term maintenance and sole source issues.

2.4 Core Replacement and approach to critical

In all likelihood the core will be removed in accordance with procedures developed at Montreal [5,7]. It is planned to transport the spent fuel using the AECL F 257 transportation flask, and the local regulatory body will be approached to license it.

For all SLOWPOKE's to date the approach to first criticality has involved adding fuel pins to the core according to a prearranged schedule using a peening process [8]. For the HEU core at ICENS the fuel loading took 15 cycles. The clear advantage of this methodology is that it has been successfully utilized with seven HEU and two LEU cores. An alternative to this process is to have the fuel cage shipped partially loaded, thereby reducing the number of cycles for the approach to critical, and the risk of damage during peening. However, the feasibility of this approach will depend greatly on how closely the modeling predictions for the core loading match past data for the LEU cores.

3. Regulatory Oversight

In January of 2011, the Government of Jamaica (GOJ), via Cabinet Decision # 01/11, designated the Ministry of Industry and Commerce the parent ministry for the Radiation Safety Authority (RSA) under the auspices of the Jamaica Bureau of Standards (JBS) (Fig 2), and enacted the Jamaica action plan (2012 – 14) with the following actions:

- A draft law compliant with the International Basic Safety Standards and related IAEA publications such as GSR Part 1 Requirements [9], the Code of Conduct on the Safety

and Security of Radioactive Sources [10], and supplementary Guidance on the Import and Export of Radioactive Sources [11], is scheduled for completion in March 2013. The IAEA is being requested to provide assistance in this effort.

- Stakeholder forums are to be convened for consultation on and review of a draft law (September 2012)
- Time-lines are to be established for actions coming out of the stakeholder consultations, for enactment of legislation

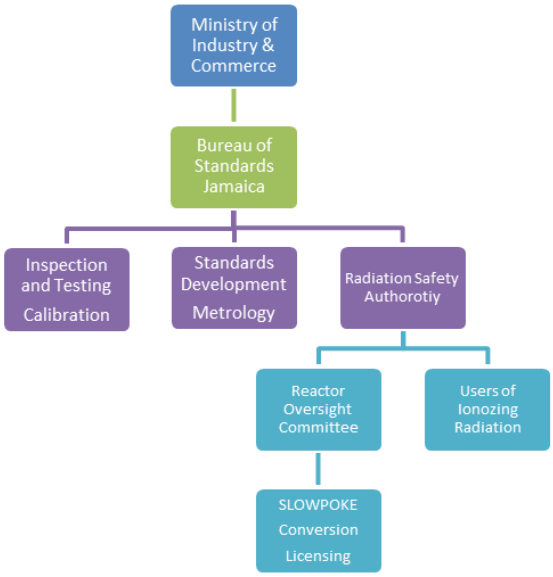

Fig. 2, Position of Radiation Safety Authority (RSA) within the Ministry of Industry and Commerce

The newly appointed RSA has established a reactor National Oversight Committee (NOC) to act as the de facto nuclear regulator, and review all operational aspects of the research reactor, to ensure that the upcoming conversion is conducted in accordance with all relevant international guidelines. This committee has thus far adopted the IAEA safety requirements document NS-R-4 "Safety of Research Reactors" as its reference document and are currently finalizing the list of documents that will be required for the conversion process.

4. Timeline of activities

The core conversion is projected to take 4 years to complete (Table 1). Work has started on the documentation requirements and national regulatory framework (lightly shaded cells of Table 1), key issues which have seen significant progress in the last year. Current efforts (darker shaded cells of Table 1) are focused on completing the licensing documentation, identifying and agreeing terms for the use of various specialized equipment for the core conversion with AECL, and finalizing contracts for core conversion work. Another key issue will be the renewal of competent authority certification from the US Department of Transport for the F-257 flask, which expired on September 30th 2012.

Activity	2011		2012				2013			2014	
Legislation & Regulatory Oversight	Cabinet Decision # 01/11 of 10 January 2011 Bureau of standards Jamaica to house RSA	Reactor Oversight Committee established in RSA	Draft Law prepared	Identification of appropriate regulations to give effect to the proposed law	Stakeholder forum to be convened for consultation on and review of draft law	IAEA agreement on regulations	Draft Guidance Documents and Codes of Conduct	BSJ will establish a national nuclear/radiation security and safety committee		Cabinet to issue drafting instructions for the regulations according to priority listing Conversion and Operating license issued	
Documentation		Statement of Work defined		Report on adequacy of reactor site and facilities Tripartite NDA Signed (AECL-ANL-ICENS) PSA signed by Jamaican Government	Report on safety and licensing documentation requirements	Completed conversion SAR reviewed by ANL staff for PSA presented December 2012 Board of Governors Meeting. Meeting on Conversion Related Activities (AECL-ANL-ICENS)	Submit documents for regulatory approval of operations /maintenance procedures for LEU fuel	Provide project quality assurance manual and other project manuals as agreed upon by ICENS and ANL staff	Submit documents for regulatory approval of conversion and operation of LEU core		
AECL							Determination of available equipment and drawings for equipment to be manufactured. Issue contracts for defueling, refueling, commissioning, health physics etc. (AECL/ANL/ICENS/Subcontractors)	Finalization of AECL involvement and use of equipment (contracts drawn)			
Facilities Upgrade							Submit documents for regulatory approval	Control System Upgrade	Safety & Utilization related upgrades		
Core Modeling							HEU-LEU cores (ANL & ICENS)				
Fuel Fabrication						Fuel and fuel cage to be fabricated by AECL with Y-12 to provide UO_2 and quality control.					
Transportation							Arrangements to be made with Savannah River Acceptance Program team and AECL for use of F257 flask (re-license)			LEU fuel delivered	HEU removed F257 flask
Installation							Dry run of the defueling fuelling procedures as well spent fuel flask removal procedures			Fuel cage to be loaded following classical approach to critical.	

Table 1, Core conversion activities timeline.

5. Conclusion

Activities for the conversion of the Jamaica SLOWPOKE core have started with funding provided by the DOE. The work will be undertaken by AECL staff, external contractors and ICENS staff. The issues of independent regulatory oversight in the Jamaican jurisdiction are being addressed and we are awaiting final drafting instructions for the regulations to be issued by the Government. The interim oversight committee will be assisted by the IAEA in the review of safety and analysis reports and other relevant documents. It is envisaged that the conversion operation from shutdown to commissioning of the new core can be completed within six weeks, and provided that the fuel fabrication process can be completed in the estimated 18 months, the project should be accomplished by the end of 2014.

In March 2014 the ICENS Jamaica SLOWPOKE will be celebrating its 30th year of operation, and a number of events are being planned to celebrate this milestone. While the focus will be on recognizing and highlighting the efforts and outputs of the institution and its staff over the years, in carrying out research and developing competences in the field of nuclear science, it is hoped that the new core will renew efforts to promote the peaceful uses of nuclear technology, and position ICENS as a catalyst for interdisciplinary programmes within the University and the Caribbean region for the next 30 years.

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