DESIGN AND CONSTRUCTION OF A DECAY POOL AT IAN-R1 RESEARCH REACTOR

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Abstract. With cooperation of the International Atomic Energy Agency (IAEA) and the Department of Energy (DOE) of the United States, several calculations and tasks related to the waste disposal of spent MTR-HEU fuel enriched nominally to 93% were carried out for the conversion of the IAN-R1 Research Reactor from MTR-HEU fuel to TRIGA-LEU fuel. In order to remove the spent MTR-HEU fuel of the core and store it safely a project was established at the Instituto de Ciencias Nucleares y Energìas Alternativas (INEA). This project included training, acquisition of hardware and software, design and construction of a decay pool, transfer of the spent HEU fuel elements into the decay pool and his final transport in 1996 to Savannah River Site in United States. In this paper are presented neutronic and shielding calculations for the decay pool concerning the storage of spent MTR-HEU fuel elements.

1. INTRODUCTION

IAN-R1 Research Reactor is a pool type with a concrete shield and two beamports. IAN-R1 is licensed for steady state operation at 30 Kw and it is located at Instituto Colombiano de Geologia y Mineria INGEOMINAS in Bogotá D.C., Colombia. IAN-R1 is a research reactor pool type which was initially fueled with MTR–HEU enriched to 93% U-235 [1], operated since 1965 to 10 kW (t) and was upgraded to 30 kW(t) in 1980. General Atomics (GA) achieved in 1997 the conversion of HEU fuel to LEU fuel TRIGA ($UzrH_{1.6}$) type enriched to 19.7%,, and upgraded the reactor power to 100 kW(t) [2].

2. DECAY POOL

The facility designed to store spent fuel at IAN-R1 consists of a storage rack located into a cylindrical tank of 4.0 m in height with 2.0 meter in diameter and 6 mm thickness Type 304 of stainless steel. The rack has a total capacity to store 30 fuel assemblies and it is made with stainless steel**.** The biological shielding is provided by the water inside the tank and by the concrete (2.3 g/cm^3) which surrounds the tank on the radial direction. A water purification system provides corrosion control and optical clarity. Control of the water purity is performed by analysis of the water conductivity with values as low as 5 μS/cm**.** The decay pool is physically independent of the reactor pool and is located inside the reactor building.

3. NEUTRONIC CALCULATIONS

The standard MTR-HEU fuel element includes 10 fuel plates having each one a 593,7 mm (length) x 62,3 mm (width) x 0,508 mm (thickness) active area. This fuel is metallic uranium alloyed with the 90% purified aluminum in the U^{235} isotope. The unit effective density is 3,32667 g/cm^3 and is contained by a 0,508 mm-thick Al-1100 clad with. 150 g of ^{235}U and 16.6715 g of ^{238}U. The core contains 16 fuel assemblies, 13 standard MTR-HEU fuel elements with 10 fuel plates/element, and 3 of the 16 fuel assemblies are control elements with 6 fuel plates/control element.

In order to establish the sub-criticality, it was evaluated a configuration of 30 storage positions occupied with standard MTR-HEU fuels. The analysis of neutron cross sections are generated for five neutron energy groups. All neutron cross sections for thermal and fast energies are generated using the WIMS code [3]. The radial and axial buckling used for obtaining cross sections were 5.487849x10-3 and 2.742174x10-3 respectively. The neutron energy group structure and cross sections are presented in Table 1.

Table 1. Neutron cross sections for MTR-HEU fuel.

Energy Inteval (eV)	**Absorption**	**Fission yields**
$1.0\ 00x10^{7}$ – $0.821x10^{6}$	$0.532001x10^{-3}$	$0.306282x10^{-3}$
$0.821x10^{-6}$ – $5.530x10^{3}$	$0.222455x10^{-3}$	$0.333768x10^{-3}$
5530 - 1.500	$0.360260x10^{-2}$	$0.399033x10^{-2}$
1.50 - 0.625	$0.785135x10^{-2}$	$0.934779x10^{-2}$
0.625 - 0.000	$0.484172x10^{-1}$	$0.673677x10^{-1}$

From diffusion code CITATION [4] a value of the effective multiplication factor K_{eff} = 0.42161 was obtained for all the storage rack loaded with standard MTR-HEU fuels.

4. SHIELDING CALCULATION

A model with MERCURE code [5] has been developed for 16 storage positions occupied with MTR-HEU spent fuel elements after 120 days the reactor was shutdown. To estimate the average irradiation burning level in the standard MTR-HEU fuel**,** the reactor operating record was considered. The kW-hour data since the year 1965 to the last operation of the IAN-R1 with MTR-HEU fuel in 1994 were taken into account. The photon spectrums for fission and activation products for evaluating dose rate distribution were taken from reference [6]. The photon spectrum for fission products of a MTR element, which was used in MERCURE is referred in table 2.

Table 2. Photon spectrum for fission products. MTR fuel element.

Energy (MeV)	**Photons/cm^{3} s**
0.575	$1.29x10^{3}$
0.85	$5.75x10^{4}$
1.25	$3.54x10^{6}$
1.75	$1.85x10^{6}$
2.25	$5.51x10^{6}$
2.75	$7.59x10^{8}$
3.50	$2.41x10^{8}$

The radiation levels for the horizontal direction due to the direct radiation from MTR-HEU fuel elements into the decay pool were evaluated through the biological shield at the mid-plane of the MTR-HEU fuel. Figures 1. and 2. show the radial and axial dose rate distribution calculated for IAN-R1 Research Reactor´s decay pool.

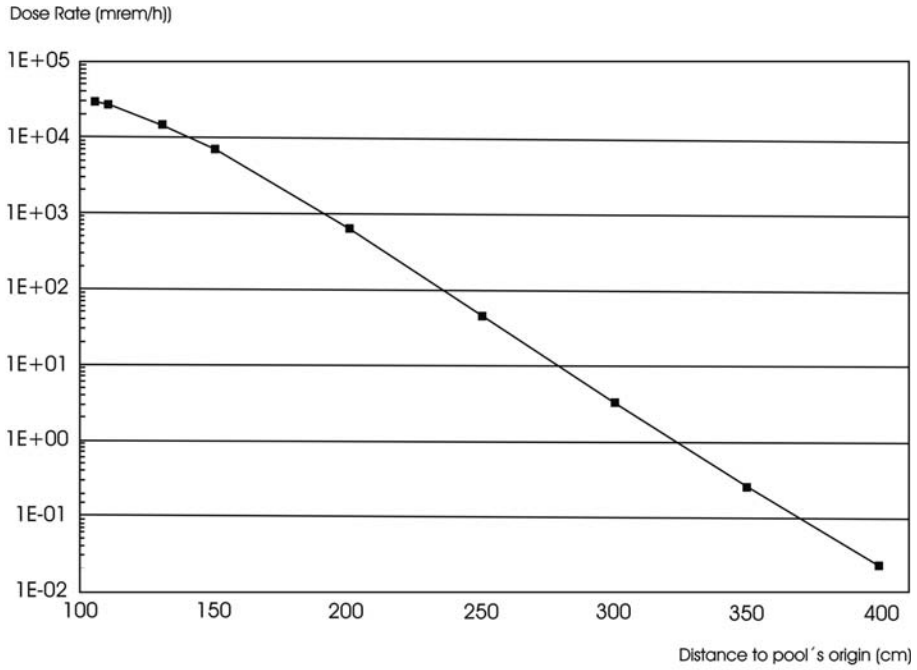

Figure. 1 Axial dose rate distribution

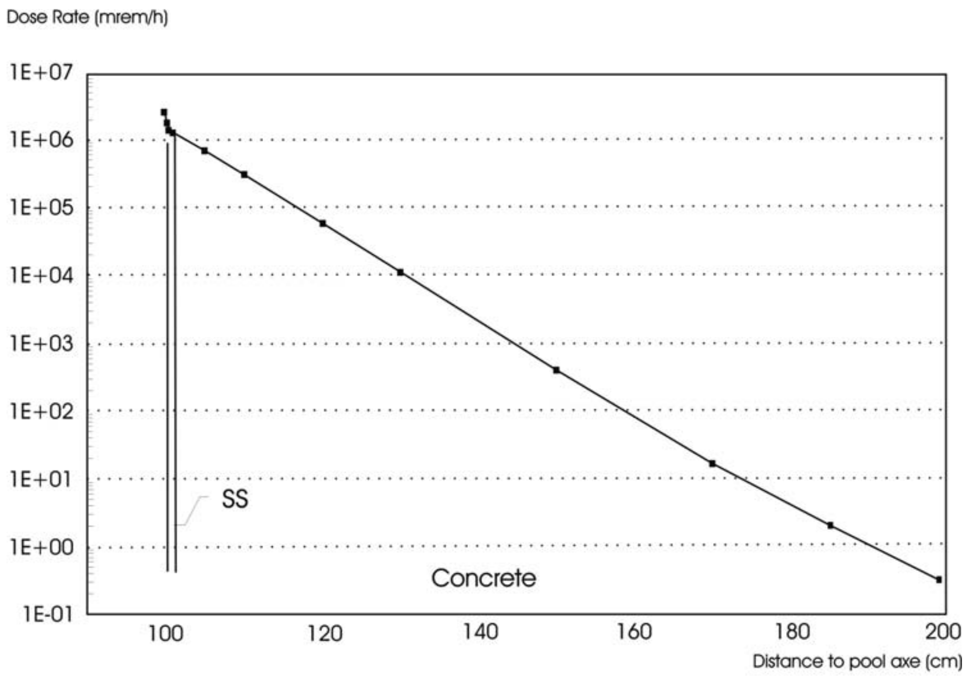

Figure. 2 Radial dose rate distribution at the fuel element axial midplane

5. CONCLUSIONS

The values obtained for the effective multiplication factor K_{eff}, and the radial and axial dose rate distribution, let conclude that the spent MTR-HEU fuel elements can be storaged securely into the decay pool designed.

Due to the low nominal power and short operation cycles, the IAN-R1 Research Reactor at INGEOMIAS actually does not generate spent LEU fuel and it is not considered to be problem. Nevertheless IAN-R1 has a facility to store all the TRIGA-LEU fuel of the reactor core and there is enough operational storage capacity of spent LEU fuel for many years of reactor operation, even if there is an increase in reactor utilisation.

ACKNOWLEDGEMENTS

This study was supported by the International Atomic Energy Agency IAEA, and the Instituto de Ciencias Nucleares y Energías Alternativas INEA. We thank to the Distrital University Francisco José de Caldas for its support, and to Osvaldo Lovotti for helpful discussions.

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