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Core Management, Operational Limits & Conditions and Safety Aspects of The Australian High Flux Reactor (HIFAR)

Dr Sue L Town
HIFAR Reactor Physicist
Nuclear Technology Division
ANSTO
PMB 1
Menai
NSW 2234
AUSTRALIA

ABSTRACT

HIFAR is a DIDO class reactor which commenced routine operation at approximately 10MW in 1960. It is principally used for production of medical radio-isotopes, scientific research using neutron scattering facilities and irradiation of silicon ingots for the electronics industry. The license to operate HIFAR is granted by an independent Government body, the Nuclear Safety Bureau.

The HIFAR reactor uses six neutron absorbing coarse control arms to maintain and control criticality. These move in vertical planes between the rows of 25 fuel elements. A detailed description of the core, including fuel types in use, will be presented. Until 1992, the arms used were cadmium coated stainless steel blades[1]. The cadmium (Cd) coarse control arms use the Cd_{113} isotope, which has a thermal resonance giving an extremely high effective cross section of approximately 27600 barns, thus making it a great candidate for neutron absorption and hence control of criticality.

However, the limitation with these type of control arms is the short lifetime in the core (transmutation of Cd_{113} to Cd_{114} necessates changing frequently) and, more importantly from a safety point of view, the rapid fall off of absorption capacity. Detailed information on these operational limitations and the safety implications will be presented. In order to extend control arm lifetimes and improve the safety implications for HIFAR, a move was made to the use of europium (Eu) tipped control arms [2,3]. Following the preparation of safety submissions [4,5], the first Eu tipped coarse control arm was loaded into the HIFAR core in November 1992. Inverse kinetics measurements were performed in order to assess the differential reactivity worth of the control arm bank prior to and after installation of this (and subsequent) Eu control arms. These measurements, in addition to reactivity measurements, will be presented and discussed in detail. During the period from November 1992 to date, any Cd control arms which have required changing have been replaced with new Eu tipped blades. The last Cd control arm was removed from the core in October this year.

The HIFAR Safety Case was first formulated and reviewed in approximately 1970. As part of the review of the HIFAR Safety Case in 1996, a full analysis of control arm operational delay, drop and insertion time data was performed[6]. This allowed a Safety Case to be developed, providing the basis for HIFAR's operational limits and conditions. Relevant physics related Operational Limits and Conditions have been revised [7] to be consistent with the current HIFAR Safety Case and the use of Eu tipped control arms. These will be discussed in detail.

Details will be given of the current fuel management program, HIFUEL [8], used by the Reactor Analysis Group to predict the reactivity loss due to burn up of fuel and the power distribution in fuel elements. Reactivity accounting is performed using HIFUEL in addition to maintaining a running reactivity total. This includes allowing for reactivity changes due to at power loads and unloads of targets from within hollow fuel element positions in the core and reactivity loss with burn up of Eu control arms [9]. Details will be provided of reactivity accounting and how this has been computerised, including fitting of reactivity loss data for Eu control arms with varying degree polynomials and computerisation of this to calculate the reactivity loss of the entire control arm bank. HIFAR is currently looking at moving to a new fuel management program HIFAM [10], which includes a 3D flux calculation and more accurate reactivity accounting.

Details of all experimental measurements associated with reactor physics analysis of HIFAR will be discussed, including coarse control arm differential reactivity measurements, rig reactivity measurements and control arm delay, drop and insertion time measurements. Differences between predicted and measured excess reactivity figures for various control arm calibrations (and different U235 core masses) will be presented. Quality System documentation (procedures and instructions) relating to reactor physics will be discussed.

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3. MG Silk and BO Wade, The Burn Up of Rare Earth Absorbers, AERE, R6526, 1970.

4. RM Godfrey, Introduction of Eu Tipped Coarse Control Arms into HIFAR, 1st 2nd and 3rd Stage Submission, June 1992.

5. SL Town, Introduction of Eu Tipped Coarse Control Arms into HIFAR, 4th Stage Submission, 1995.

6. SL Town, Review of Operational Coarse Control Arm delay, drop and insertion time measurements, 1995

7. SL Town, Review of Physics Related Operational Limits and Conditions, 1996.

8. GS Robinson, A Brief Description of HIFUEL, a fuel management program for HIFAR, Technical Note TN26, April 1987.

9. GS Robinson, 3D Diffusion Calculations of HIFAR, E703, September 1991.

10. GS Robinson, HIFAM A Computational Model for HIFAR Fuel Management, TN192, October 1994.