ABSTRACT

Since last RERTR meeting, several tasks involving RERTR activities continued deploying in Argentina: through an agreement between CNEA and US-DoE final steps in the RA-6 reactor core conversion from HEU to LEU are taking place; by means of a return campaign of 42 US origin SNF in the frame of the US-SNF FRR program; an effective minimization of HEU inventory is close to be accomplished; development of a LEU dispersed U-Mo fuel prototype, to be irradiated in a high flux reactor in the frame of the ARG/4/092 IAEA's Technical Cooperation project is progressing; very high density monolithic U-Mo miniplates and plates using MEU and LEU fuel with Zry-4 cladding were developed to be irradiated as a part of the RERTR program irradiation experiment; atomistic modeling prediction (BFS techniques and first principles) enabled to find some trends on the interaction phases; diffusion couples tests under X-ray synchrotron analysis allowed the characterization of several phases involving U-Mo(-Zr) / Al(-Si); finally CNEA continued spreading high quality LEU technology for fission RI production by means of agreements with different producers interested on HEU-LEU conversion.

1. Introduction

During 2007 RERTR R&D activities in CNEA were focused on

• Final steps on the RA-6 reactor core conversion project from HEU to LEU fuel.
• An effective minimization of HEU inventory in Argentina is close to be accomplished.
• Continuing on a deeper and comprehensive understanding of U-Mo(-Zr)/Al(-Si) and U-Mo/Zry-4 alloys interaction zone formation in dispersed and monolithic fuels. A special work will be presented in technical sessions
• Developing promissory solutions for VHD monolithic and dispersed fuels,
• CNEA continued deploying R&D on LEU target and radiochemical technology for radioisotope production, meeting international quality standards.

2. RA-6 conversion

RA-6 reactor is a pool-type one with a thermal power of 0.5MW, sited in Bariloche Atomic Center, Province of Rio Negro, Argentina. It is mainly dedicated to human resource training on Nuclear Engineering, Reactor Physics and Reactor Operation and Control. Also Neutron Activation Analysis and BNCT experimental therapy on melanoma cancer are regular activities. Since its inauguration in 1983 until June 30th, 2007 the reactor worked using HEU cores. On October 30th, 2005 two contracts
between CNEA and NNSA-DoE were signed to give place to the core conversion, to minimize the use of HEU in our research reactors and fission radioisotope production, and to take part of the FRR SNF program to return to USA US origin HEU spent nuclear fuels. Final tasks in this direction are nowadays taking place:

- On August 4th, 2006 CNEA and NNSA-DoE achieved the swapping of HEU-LEU inventories which enabled the production of LEU U₃Si₂ for the replacement core.
- On June 30th, 2007 CNEA definitively finished the use of HEU core for the RA-6 reactor. Those fuel assemblies were removed and temporarily stored in the auxiliary pool, waiting to cool down and to be conditioned for the transport campaign.
- Replacement new LEU U₃Si₂ based fuel assemblies, 4.8 g/cc density in meat, with Cd wire as neutronic poison were fabricated in CNEA’s ECRI plant. Formal RA-6 reactor core conversion is taking place.
- Interim storage casks fabricated in CNEA by the Radioactive Waste Management National Program to be stored at RA-6 reactor building to contain LL and ML wastes produced during the fuel conditioning task (mainly used nozzles, handlings and screws and also exhausted ionic-exchange resins from the water purifying system).
- An exportation campaign of 42 HEU SNF is close to be finished.

3. Very High Density fuel development
Main efforts in this direction are:

- In the frame of the IAEA’s Technical Cooperation, the project ARG/4/092 to irradiate and PIE in a high flux reactor a full scale fuel assembly prototype is making progress. This prototype will consist in an Al cladding - fuel dispersion of LEU-Mo particles in an Al-Si matrix, 8gU/cc. Irradiation and PIE technical specifications were sent to TC for starting the tender process and call for bids.
- Development of U-Mo monolithic fuels with Zry-4 cladding continued. Special arrangements to prepare in Argentina and irradiate in high flux reactors US origin MEU (58%) samples are progressing. The work is focused on testing such specimens. This initiative is partially held by a contract between BEA( LLC)(INL-DoE)-CNEA for the provision of several U-Mo monolithic miniplates and plates for irradiation in the frame of the RERTR tests.
- FSW bonding techniques: during 2007 continued the development of FSW bonding techniques to full scale U-Mo monolithic fuel Al cladding plates.
- Methods for U-Mo powder production: a project to evaluate the production of U-Mo particles started. The methods under testing are industrial laser ablation, high power plasma ablation and electro-spark machining. Preliminary results are promissory.

4. Characterization of out-of-pile diffusion couples behavior under temperature treatment tests
- Out-of-pile tests: through several irradiations with high intensity synchrotron X-rays diffraction techniques performed in the LNLS Campinas, Brazil, the characterization of phases in the interaction layer, after 340°C and 550°C temperature treatment in diffusion couple samples of U-Mo(-Zr) / Al(-Si) was possible to improve. A special work will be presented during technical sessions.

5 Theoretical calculation of alloys formation
o Theoretical calculation using BFS (Bozzolo, Ferrante Smith, 1992) method for determining the atomic system energy as a function of its geometrical configuration: this methodology provides a virtual model of an alloy formation process. During this year started the extension of the method to include interactions behind second neighbors and interphases between two different crystallographic structures.

o UZrNb/Al – UZrNb/Zr systems interaction layer studies: simulations suggested that neither Zr nor Nb presence in alloy avoided the Al-U interaction layer formation3.

6. Improvement of the LEU target and radiochemical technology for Mo99 and other radioisotopes production.
  • Due to the final restriction on the supply of HEU material for the production of fission Mo99, CNEA has decided on 2001 to turn into LEU material for target fabrication.
  • It was done maintaining other characteristics of the production, i.e. the alkaline chemical process. CNEA achieved successfully an adequate replacement meat.
  • Our LEU technology satisfies the most stringent requirements of quality for its use in nuclear medicine applications.
  • This LEU technology was sold to ANSTO (Australia) and Egypt’s EAEA.
  • In September 2005, CNEA began the regular production of high quality fission I-131, a by-product of Mo-99 production, meeting international quality standards.
  • CNEA has a project in progress to optimize the Mo99 production (CiMo99/grU).
  • CNEA-US DoE collaboration on LEU technologies: during Dec. 2006, USDoE monolithic LEU targets and a process digestor were tested at the RA-3 reactor and production plant with promissory results.
  • A project to recover irradiated HEU, blend it down to LEU and separate Cs137 and Sr90 is ongoing. The separation of Sr-90 will be used as a precursor in Y-90 generators, while the recovered Cs 137 will be used to produce tubes for brachiotherapy applications.
  • CNEA is participating in the IAEA Coordinated Research Project on developing techniques for small scale indigenous LEU Mo99 production as an agreement holder

7. Conclusions

CNEA continued deploying an intensive activity on R&D on RERTR technologies. The minimization of the use of HEU in Argentina was achieved. Concerning VHD fuels, we focused our work on the design of a prototype of Al/Si cladding - fuel dispersion of LEU-Mo particles in an Al-Si matrix, 8gU/cc for its irradiation through an IAEA’s TC ARG/4/092 project. Other lines includes the irradiation of monolithic ME U-Mo fuel (58% at.U^{235}) / Zry-4 cladding samples in high flux reactors. Concerning LEU technologies for radioisotope production we are deeply involved on the optimization and diffusion of this technology. Future plans includes:
  • Final steps in the 42 HEU SNF return campaign as a part of FRR SNF program
  • Irradiation of the dispersed U-Mo / Al-Si prototype and monolithic U-Mo /Zry-4 cladding VHD samples in high flux reactors
  • Optimization of LEU target and radiochemical techniques for radioisotope production

8. References
1 Aricó S, Mirandou M, Balart S, Komar Varela C, Gribaudo L. “Experiencias de difracción de rayos X de muy alta intensidad en pares de difusión U-Mo-X / Al-Y realizadas en el LNLS, Campinas, Brasil” 8º Reunión del Ciclo de Combustible, CNEA, 13/9/2007, Buenos Aires, Argentina
3 Garcés J, Bozzolo G. Mosca H “Extensión del método BFS a mayores de segundos vecinos y su efecto en combustibles de alta densidad” 8º Reunión del Ciclo de Combustible, CNEA, 14/9/2007, Buenos Aires, Argentina