THE LFR FACILITY (CNEA) FOR BURNUP DETERMINATION IN URANIUM SILICIDE FUELS 20% ^{235}U

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Abstract

The LFR Facility is a radiochemical laboratory designed and constructed with a hot-cells line, a glove-box and a fume-hood, all of them suited to work with radioactive materials.

At the beginning of the LFR operation a series of dissolutions of MTR irradiated silicide fuel elements was performed, and determined its isotopic composition of ^{235}U, ^{239}Pu and ^{148}Nd (this last as burnup monitor), by the thermal ionization mass spectrometry (TIMS). These assays are linked to the IAEA RLA/4/018 Regional Project "Management of Spent Fuel from Research Reactors". It is concluded that this technique of burnup measurement is powerful and accurate when properly applied, and permit to validate the calculation codes when isotopic dilution is performed.

It is worth noticed the LFR capacity to carry on different research and development programs (R+D) in the Nuclear Fuel Cycle field, such as the previously mentioned absolute burnup measurements, or the evaluation of radioactive waste immobilization processes and researches on burnable poisons.

1.- INTRODUCTION

The LFR Facility is sited in the Ezeiza Atomic Center of the National Atomic Energy Commission of Argentina. In the *Fig. 1*, it is possible to appreciate the internal distribution of the different sectors.

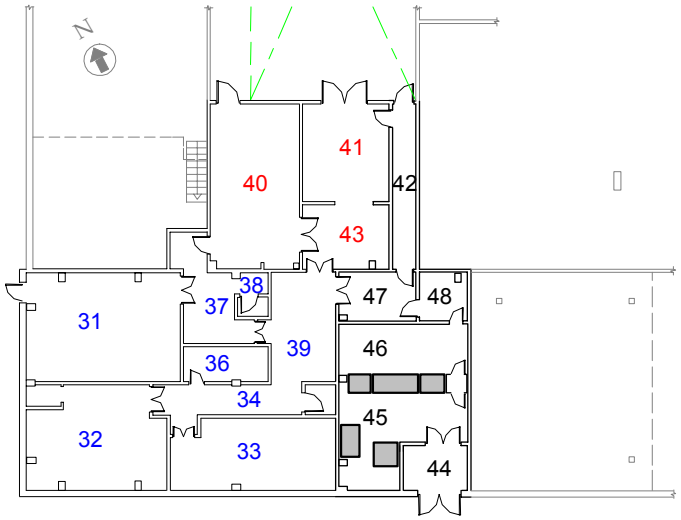

Fig. 1 – LFR Facility ground level.

The LFR ventilation system includes an Extraction Room and a Filtration Room both of then on first floor *(Fig. 2 and 3)*.

Fig. 2 – LFR Extraction Room.

Fig. 3 – LFR Filtration Room.

The hot-cells line was built with 10cm thickness of lead-shielding, mounted with master-slave manipulators and remote handling tools, with HEPA filtration system and double door air tight transfer system between cells. Two of the cells, with sealed enclosures and with alpha tight protecting booting, are suited to work with radioactive materials *(Fig. 4, 5 and 6)*.

Fig. 4 – Metallic frame for the shielding and internal sealed enclosures for cells numbers 1 and 2.

Fig. 5 – Frontal view of LFR hot-cells line *(Supervised Area).*

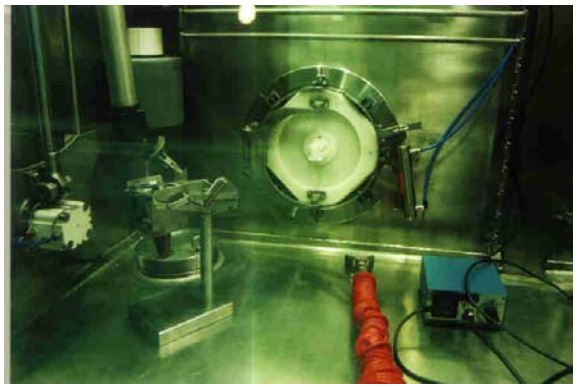

Fig. 6 – Internal view of hot-cell Number 2.

It's possible to operate as well with 10 Ci of Beta-Gamma fission products and with Alpha emitters materials. Inside Cell 2, there are two extra attached shielded containers. This containers storage active materials, and reduce the total dose rate applied to the rest of the components.
In the Controlled Area there are two main components, the Glove-Box and the Fume-Hood, as well as the "Padirac" and "La Calhene" transfer systems *(Fig. 7 and 8)*.

Fig. 7 – LFR Glove-Box with the HPLC system.

Fig. 8 – LFR hot-cells line, rear view (Controlled Area).

In the Glove-Box it is installed the high performance liquid chromatography (HPLC) system. The high pressure chromatographic pump, the post column reactor (PCR) and the UV-visible detector are mounted outside the box. The injection sample valve with a 100 µl sample loop, the switching valve for fraction collection, and the analytical column were placed inside. The column is packed with C-18 reversed phase on a suitable support.
By means of this chromatographic technique it is possible to separate neodymium (as burnup monitor) from the other fission products, avoiding the isobaric interferences during the mass spectrometric analysis.

2.- METHODOLOGY

The MTR fuel samples were dissolved and sampled in the Cell 2. A small aliquot is transferred to the Glove-Box for the HPLC separation. Both collected fractions (neodymium and also U+Pu) were loaded on different rhenium filaments for the isotopic analysis.
Other samples, previously to the chromatographic run, were blended with known amounts of certified spikes of enriched ^{233}U and ^{150}Nd solutions. These isotopes are not present in significant quantities in the spent fuel. Due to isotopic dilution of the spikes produced by the isotopes present in the sample, it is possible to calculate the actual ^{148}Nd and U concentration, of the spent fuel sample.
With the use of spikes and on the basis of isotopic ratios, the quantitative determination of elements in the fuel is possible.
Any loss after the spiking process, will affect in the same way both isotopes -from the spike and from the fuel-, and will not change the isotopic ratio. After the blending and equilibration, the chemical separation does not need to be quantitative. Any change of volume or loss of material does not affect the final result.

The process flow sheet *(Fig. 9)* summarizes the fuel burnup material processing, in the LFR.
The separation of actinides has not been performed up to now, and due to it, an isobaric interference at masses 238 (U-Pu), decreases the confidence on the Pu results.

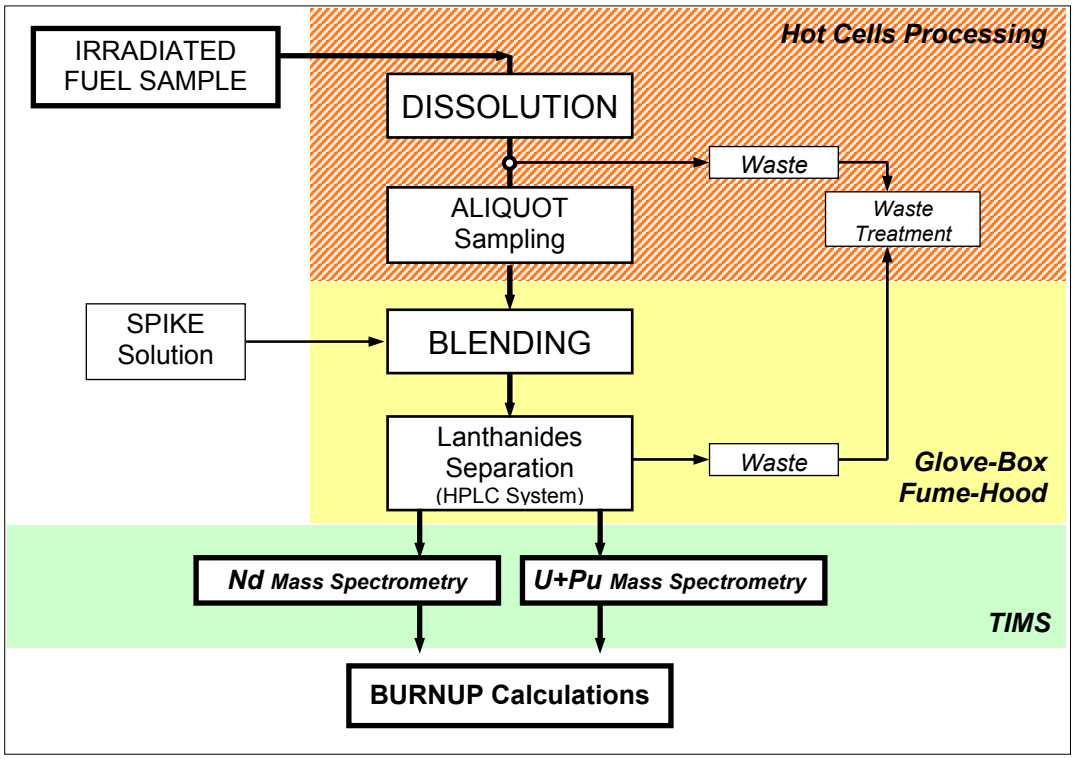

Fig 9 – Normal Processing of Material in the LFR

Fig 10 shows the separation of the natural lanthanides by HPLC system, while *Fig. 11* shows the separation of U+Pu and Nd in a real sample by the same technique.

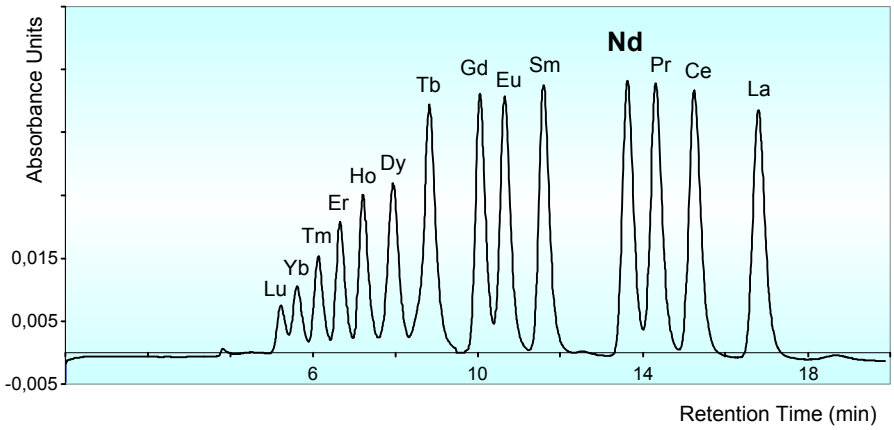

Fig10 – Gradient Separation of the Lanthanides.

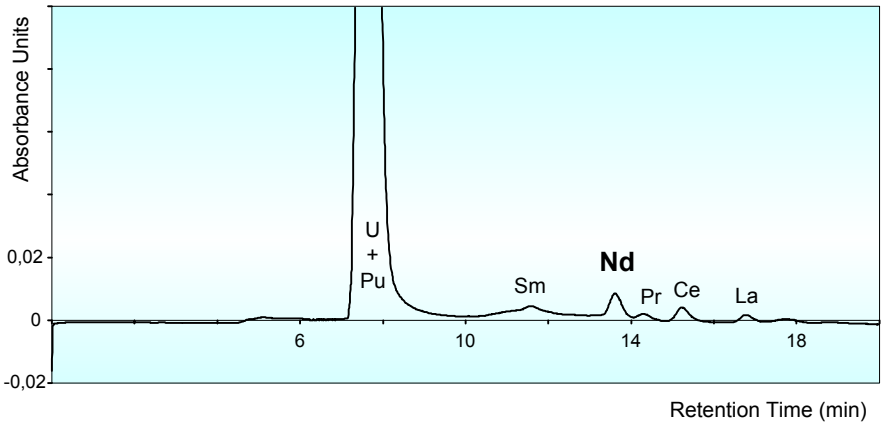

Fig10 – Gradient Separation of Lanthanide Fission Products in Irradiated U-Si MTR Fuel.

3.- RESULTS AND DISCUSSION

As an approach of the burnup determination, the depletion of ^{235}U in the spent fuels was measured. In *Table 1* it is possible to compare the isotopic composition of the fresh and some samples of the irradiated fuel plates.

Sample	U (%w)			Pu (%w)			
	234	235	236	239	240	241	242
Fresh Fuel	***0,132***	***19,74***	***< 0,020***	- -	- -	- -	- -
10	0,109	15,44	1,020	88,73	9,26	1,89	0,13
11	0,109	13,89	1,287	88,32	11,11	2,37	0,19
20	0,110	14,83	1,125	87,07	10,12	2,58	0,22

Table 1 – Isotopic composition of different samples

This work shows the capability of the LFR facility for destructive assays in burnup determinations of irradiated nuclear fuels.
In the near future, it will be reported the results of the analysis for absolute burnup determination when neodymium fission monitor is employed. These measurements allow to validate the calculation codes employed in the nuclear field for the design and in-core management of the fuel elements.
This assays are linked to the IAEA RLA/4/018 Regional Project "Management of Spent Fuel from Research Reactors".

Acknowledgement

The authors wish to recognize the assistance of Ricardo Garavaglia and Alfredo Lobo, U.A. Química, for the isotopic analysis.

4.- REFERENCES

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