Advanced fuel cycles for Accelerator Driven Systems: Hot Laboratory availability for PIE on MA-bearing fuels and targets.

M. Verwerft
SCK•CEN, Boeretang 200, 2400 Mol, Belgium

The review of the European hot laboratories [1], shows that no specific regulations pertain to the acceptance of irradiated targets containing minor actinides. In general, it is quoted that the presence of trace amounts of the minor actinides "as present in irradiated nuclear fuel" is accepted in the fuel hot cells. Limits on the amount of fuel that can be present in the hot-cells are based on gamma dose rate and potential criticality.

Let us first consider the order of magnitude of the quantity of minor actinides present in irradiated nuclear fuel. As an example, we assume that ten full length fuel rods are allowed in the NDT (non-destructive testing) hot cell, which roughly corresponds to 25 kg of irradiated fuel. The concentration of minor actinides in irradiated fuel of a burnup of 55 GWd/tHM and a cooling time of one year, is given in table 1. In one kilogram of irradiated UO_2, one has about 0.25g of Am and 0.1g of Cm. In the case of MOX fuel, the amounts of both Am and Cm are significantly higher: about 1.8g of Am and 1g of Cm, again per kilogram of fuel. This means that according to the current regulations, one accepts 6 g of Am and 2.5 g of Cm in the case of UO_2 rods and up to 45 g of Am and 25 g of Cm dispersed in ten irradiated MOX fuel rods. While the dose rate and contamination risk may be acceptable when the minor actinides are embedded in the irradiated fuel rods, this will not automatically be the case for targets containing elevated concentrations of the concerned MA's.

The beta/gamma shielding of hot-cells that are currently in use for research on nuclear fuel obviously is sufficient regarding the gamma activity of targets containing high concentrations of the minor actinides. The leak tightness of the shielding may be problematic for some hot laboratories, especially with regard to the acceptance of targets that are damaged. When calculating the radiotoxicity of Pu, Am and Cm on the basis of the isotopic compsition given in table 1, and expressing the annual limit of intake (ALI) as a function of weight, one finds that the ALI of Americium is of the same order as that of Plutonium while for Curium the ALI is two orders of magnitude lower. In view of the high radiotoxicity of the considered isotopes, it will be imperative to have leak-tight hot-cells in which irradiated targets containing high amounts of Am and Cm are to be handled and/or investigated. There are, at present, several hot-laboratories that do have glove boxes inside their hot-cells. Regarding the shielding for neutrons, a more elaborate study should be carried out. At present, there is no specific neutron shielding of the hot-cells that are currently used for the investigation of irradiated fuel. For the fabrication of actinide fuels and targets, a new laboratory is under construction at ITU. It will be commissioned in the year 2001. It consists in 10 glove-boxes, equipped with the necessary shielding and remote operation to permit the fabrication of highly radioactive elements. The laboratory includes the complete pin processing, from the minor actinides solutions (or oxide powders), to the pellets fabrication and fuel pin welding and final controls. The main part of the laboratory consists of 7 boxes with lead and water shielding to permit handling of up to 150 g ^{241}Am and 5 g of ^{244}Cm. In these boxes, the reference powder fabrication process is the infiltration method. This process was selected for its minimal dust and liquid waste production rates. The 3 remaining boxes are equipped to handle up to 50g ^{241}Am, using the sol-gel process for powder preparation.This process is also dust-free, but produces liquid waste which should be avoided in particular for curium handling. Other laboratories do have actinide handling cells, but none of these has specific neutron shielding or high gamma shielding.

Coming back to the problem of post-irradiation examination, the following conclusions on the status of the European infrastructure can be drawn.

- There are no specific problems to be expected for the investigations of *intact targets* with *low concentration of neutron emitters*. The required gamma shielding for the investigation of irradiated MA targets is not different from the shielding necessary to investigate irradiated fuel pins. The situation is changed when the targets might either be defective or when the investigations are not limited to NDT alone.
- In view of their high specific radiotoxicity, investigations on open sources of MA targets are to be conducted inside leak-tight glove boxes. Although not every laboratory has its full chain of cells equipped with inner glove boxes, this is the case for some hot labs and most of the hot labs have at least one cell equipped with a glove boxe. Past experience with Pu containing fuels is relevant to this aspect of the investigations.

- When MA targets with elevated concentrations of Cm are to be investigated, one should specifically look at the problem of neutron dose, as the current hot cells are not specifically designed for high neutron-emitting samples. It seems logic that a full assessment of the acceptance limits on irradiated MA containing targets should be made in the near future. One should then look at the entire flowchart of the examinations to be carried out and the type of work that is to be performed in each of the utilized cells.

Table I Concentration of the minor actinides in irradiated UO_2 and MOX fuel at BU of 54 and 56 GWd/tHM respectively, one year after end-of-burnup (EOB +1) (data calculated on the basis of experimental results obtained in the framework of the ARIANE project).

Actinide	***UO_2*** *(wt%)*	***MOX*** *(wt%)*	***ALI** (intake)* *(g)*	***ALI** (inhalation)* *(g)*
237Np	6.24E-02	1.27E-02		
Np (all)	**0.062**	**0.013**	**7.E-03**	**4.E-05**
238Pu	2.74E-02	1.00E-01		
239Pu	3.42E-01	5.43E-01		
240Pu	2.39E-01	1.00E+00		
241Pu	9.63E-02	3.97E-01		
242Pu	7.53E-02	5.80E-01		
244Pu	7.05E-06	1.00E-04		
Pu (all)	**0.780**	**2.62**	**2.E-06**	**1.E-08**
241Am	8.30E-03	4.53E-02		
242Am	6.11E-05	5.90E-04		
243Am	1.52E-02	1.34E-01		
Am (all)	**0.024**	**0.180**	**2.E-06**	**1.E-08**
242Cm	1.87E-03	3.28E-03		
243Cm	4.68E-05	5.93E-04		
244Cm	6.46E-03	9.33E-02		
245Cm	2.95E-04	6.49E-03		
246Cm	6.52E-05	1.62E-03		
Cm (all)	**0.009**	**0.105**	**3.E-08**	**1.E-10**

Reference

1. *Advanced fuel cycles for accelerator driven systems: fuel fabrication and reprocessing* R.J.M. Konings (Ed.), T. Abram, M. Burghartz, P. Diaz-Arocas, J.P. Glatz, D. Haas, H. Kleykamp, J. Lacquement, G. Marucci, G. Modolo, G. Mühling, P.W. Phlippen, S. Pillon, M. Verwerft and J. Wallenius, Report of the Fuel and Fuel Processing subgroup, Institute for Transuranium Elements, 2001. ISBN 92-894-1999-7