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HFR-EU1 Irradiation Report and Non-Destructive PIE

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JRC TECHNICAL REPORT

HFR-EU1 Irradiation Report

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Deliverable D32.11 for the FP7 ARCHER Project

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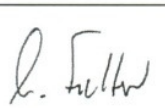
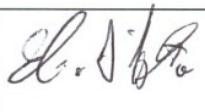
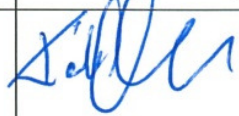
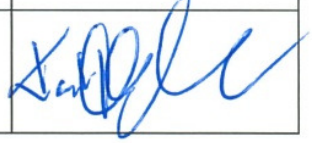
Signature				

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Summary

This report documents the transfer of information related to the HFR-EU1 irradiation from JRC to IRSN performed in June 2012. As part of ARCHER SP3.2, this information was required by IRSN to perform the related modelling task.

Approval

Rev.	Short description	First author	WP Leader	SP leader	Coordinator
0	First issue	M. A. Fütterer (JRC) 16/12/2014	S. Knol (NRG)	M. Laurie (JRC)	S. Knol (NRG)

Distribution list

Name	Organisation	Comments
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Table of contents

1. Introduction

The purpose of this report is to document that JRC has fulfilled its commitments to ARCHER Task 3.2.3 "HFR-EU1 Irradiation modeling" in the form of the deliverable D32.11 "Detailed irradiation report from the HFR EU1 test including non-destructive PIE".

Several benchmarks (as in the one performed on the HFR-EU1bis irradiation test) have indicated that the prediction of certain nuclides (e.g. Ag-110m and Am-242m) has to be significantly improved, especially due to their importance in release from coated particle fuel. Am is of major importance in recycling strategy and the evaluation of heat production in the spent fuel (through Pu-238 generation). The Am-241 (n,ɣ) Am-242g and Am-241 (n,ɣ) Am-242m reactions are good examples: even though Am-242g and Am-242m are essentially the same nuclide, they exhibit very different transmutation paths, leading to Pu-238 or higher Am and Cm isotopes. The isomeric branching ratio values change as a function of burn-up and the reactor spectrum. However, most depletion codes use a single average value for the isomeric branching ratio of a given reaction while the data available in evaluated nuclear libraries are generally dependent on the incident neutron energy.

Improving the prediction of metastable nuclides requires proper quantification of the isomeric branching ratios, both initially and as a function of time. Here the VESTA Monte Carlo depletion code had to provide a detailed analysis on both HFR-EU1 and HFR-EU1bis experiments in collaboration with NRG and JRC who provided the key irradiation data.

This task was divided into three steps:

- An evaluation phase of the isomeric branching ratio data currently available, either in evaluated nuclear data libraries, code libraries or experimental data and to make the necessary changes to the VESTA code and its data libraries to properly estimate the value of the isomeric branching ratio as a function of burn-up (IRSN).
- In parallel, collection and post processing of the fission gas release data analysis and preparation of data packages containing temperatures, burn-up estimates and gamma spectrometry measurements, was performed by JRC. This was done for HFR-EU1 and is the subject of this deliverable.
- A phase in which VESTA was used to calculate the HFR-EU1bis experiment (for which the data are already available) and the data obtained from the analysis of HFR-EU1 experiment. These calculations were then used to provide input data for fuel performance codes (burn-up dependent reaction rates, etc.) for other partners in the ARCHER project.

2. Information and Data Transferred

The following information was transferred electronically to IRSN in June 2012 and was used to prepare Deliverable D32.31 issued by IRSN:

Wim Haeck, HFR-EU1 depletion calculations, ARCHER Project Deliverable D32.31, IRSN report no PSN-EXP/SNC/2014-135, June 2014.

1. MCNP calculations: These were performed for HFR-EU1 in detail which led to an estimated burn-up which JRC had published in the following paper: M. Laurie, A. Marmier, G. Berg, J.-M. Lapetite, M. A. Fütterer, Chunhe Tang, Results of the HFR-EU1 Fuel Irradiation of INET and AVR Pebbles in the HFR Petten, Nuclear Engineering and Design 251 (2012) 117-123.
NRG had performed these calculations for JRC because NRG have a detailed MCNP model of the core and the experiments around. This includes a power and depletion analysis which was complicated because the experiment has moved around in the HFR core quite a bit and was also interrupted several times. From this information, IRSN could evaluate in which areas they could add value to existing results.

2. Irradiation Progress Reports: The available irradiation progress reports were transferred with updated neutronics data based on computations. They offer the 4-group neutron fluxes and fluences and expected gamma heating as well as the power densities.

3. Analysis of the flux monitor sets: These are small pieces of metal which are irradiated together with the fuel. From the activation of these metals, the received neutron fluence and spectrum was deduced. The analysis concluded that the highest loaded pebble had received a fast fluence (>0.1 MeV) of 6.34E25 m^{-2} which would be 28% more than what was calculated (4.951E25 m^{-2}).

4. Burn-up measurements: The achieved burnup of the HFR-EU1 fuel pebbles was measured with the Cs-137 method at JRC-ITU once the pebbles were shipped there. JRC-ITU has provided this information separately.