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Online measurement of fission products release during nuclear fuel annealing : A mass spectrometry approach

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In order to increase fuel rod performance, the basic mechanisms that promote gas (i.e. He, H2, Kr and Xe) release from irradiated nuclear fuels must be studied. In this context, the CEA fuel study department at Cadarache decided to improve its experimental facility devoted to fuel behaviour under thermal transient by modifying the existing annealing device, called MERARG-II, to extend the studies of gamma emitter fission gases to all gases (including Helium and hydrogen) with a complete isotopic distribution capability.

As a consequence, a joint research program between Aix Marseille University and CEA Cadarache was built in order to develop a mass spectrometer apparatus with a sampling device adapted to MERAG-II sweeping line for monitoring gaseous fission products at very low threshold levels and response times.

A Residual Gas Analyser (RGA) mass spectrometer type is used as a process-monitoring device. The mass analyser is thus enclosed in a small vacuum chamber. The RGA is equipped with a two-stage pressure converter sampling-device to adapt the pressure drop between the vacuum chamber and MERARG-II line at 1.2 bar. The sampling device also insures both no mass-segregation and the fastest transportation times (about 1 s) of neutral particles toward the ion source of the mass analyser. The sampling device operates according to two modes: (a) online measurement (for release kinetic) and (b) a static mode to reproduce the delayed measurement of capacities containing the total quantity of released gases.

After having described briefly the MERARG-II facility, the paper deals with two main axes:
• present the modelling of gas sampling inlet device and its performance. In particular, we will focus on the balance equations at the steady state for gas throughput to estimate pressures and flows for dimensioning the sampling device and the pumping system.
• give a concise review of the main aspects of the qualification/calibration phase of the RGA type analyser. We will then discuss results recorded over three mass ranges 1-10 u, 80-90 u and 120-140 u in the two classical mode of MERARG-II, i.e. on-line and off-line measurements. Then, we will detail the corresponding detection limitation of this RGA (less than 1 ppm).

Primary author: Ms GUIGUES, Elodie (LISA)

Co-authors: Dr JANULYTE, Aurika (LISA); Prof. ANDRE, Jacques (LISA); Dr PONTILLON, Yves (CEA); Prof. ZEREGA, Yves (LISA)

Presenter: Ms GUIGUES, Elodie (LISA)

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