BR2 REACTOR: IRRADIATION OF FUELS

Background

Safe, reliable and economical operation of reactor fuels, both UO_2 and MOX types, requires in-pile testing and qualification up to high target burn-up levels. In-pile testing of advanced fuels for improved performance is also mandatory.

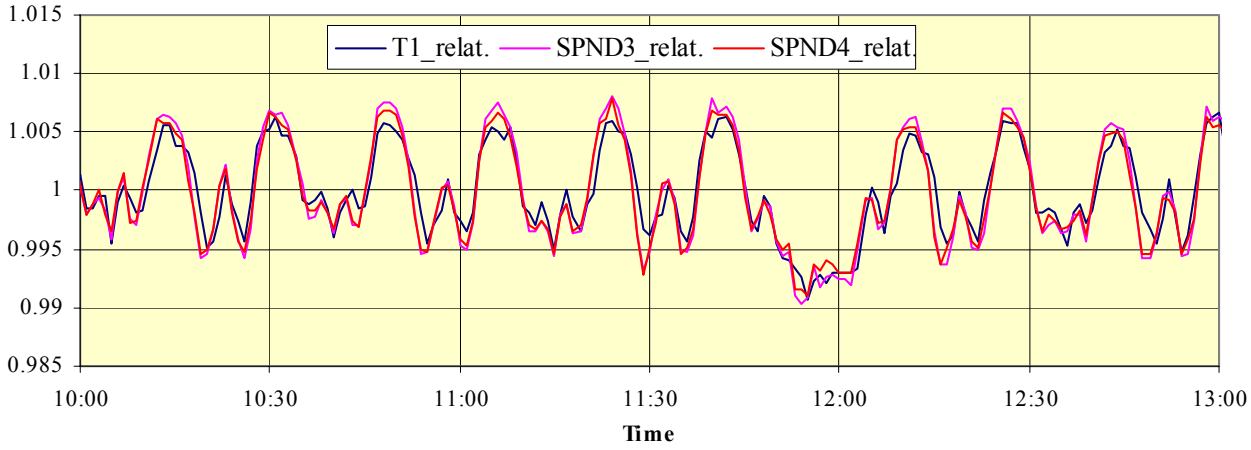
Objectives

- Neutron irradiation of LWR (Light Water Reactor) fuels in the BR2 reactor under relevant operating and monitoring conditions, as specified by the experimenter's requirements.
- Improvement of the on-line measurements on the fuel rods themselves.

Principal results

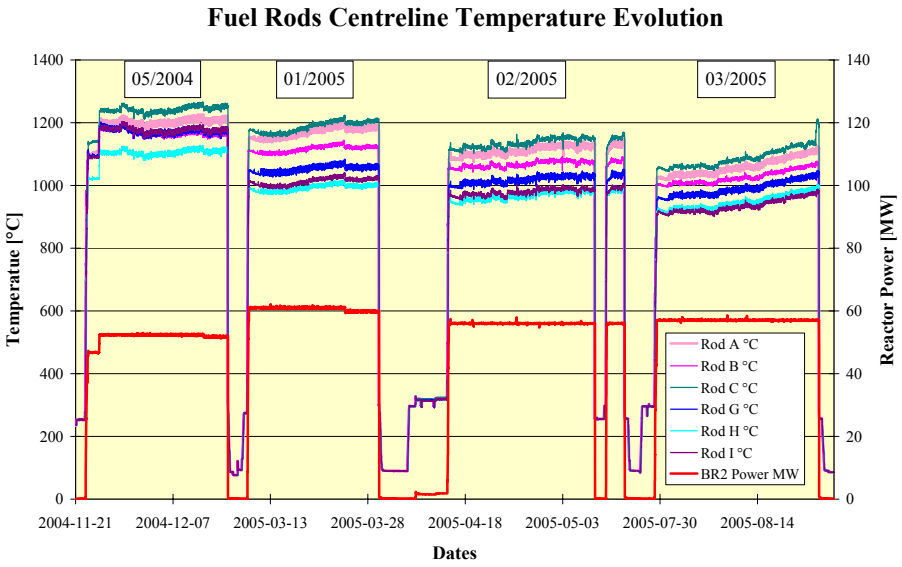
In 2005 the OMICO (Oxide fuels: MIcrostructure and COmposition Variations)-MIMAS-PV (MIMAS Process Variation) program has continued. A twin bundle consisting of 8 instrumented- and 8 non-instrumented fuel pins is being tested in the high-pressure high-temperature loop CALLISTO under typical PWR-conditions (155 bar, 300°C, controlled PWR water chemistry). The bundle comprises UO_2, $(U,Pu)O_2$ as well as $(Th,Pu)O_2$ pins. Each pin in the upper part of the twin bundle is provided with a gas pressure transducer connected via the upper end plug and a high temperature thermocouple type W5/W26 connected via the lower end plug. A total number of 40 instrumentation wires are installed on the pins and in the upstream and downstream section of the fuel bundle. The lower basket containing the 8 non-instrumented pins has been removed after the first irradiation cycle for hot-cell examinations and power calibration purpose. It has been coupled again to the upper basket, the irradiation could then be resumed with both the instrumented and the non-instrumented bundles.

The thermal neutron flux at the level of the instrumented rods was monitored on-line by SPNDs (self-powered neutron detectors) with rhodium and vanadium emitters, positioned in-between the fuel rods. The signals of the V SPNDs were strongly influenced by beta rays which were emitted by fission products in the OMICO fuel and stopped in the vanadium, limiting the reliability of this type of SPND for neutron flux monitoring near fuel rods. The observed amplitude and time evolution of this fuel beta contribution are in good agreement with the results from detailed Monte Carlo calculations. The Rh SPNDs on the other hand yielded excellent results, with absolute neutron flux data in agreement with full BR2 core Monte Carlo calculations and with accurate monitoring of flux changes down to the 0.1 % level, as illustrated below.



Normalized central fuel temperature data (T1) and rhodium SPND signals corrected for delayed response. Both the temperature and SPND data follow closely small changes in irradiation conditions due to SIDONIE movements.

The centreline temperature reflects also the power gradient between the fuel rods in the bundle; next picture shows the centreline temperature evolution of the six instrumented rods from the OMICO programme during the four first irradiation cycles.



Centerline temperature of the instrumented rods A, B, C, G, H and I in the OMICO bundle during cycle 05/2004 till 03/2005

Future work

After solving the problem due to a rod failure in cycle 03/2005, it is foreseen to resume irradiation of the OMICO fuel bundle for achieving a burn-up of 25 GWd/tM and 2-5% fission gas release.

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Main reference

L. Vermeeren, J. Dekeyser, Ph. Gouat, S. Kalcheva, V. Kuzminov, A. Verwimp, M. Wéber, *"Qualification of the on-line power determination of fuel elements in irradiation devices in the BR2 reactor"*, SCK•CEN BLG-1006 Report, January 2005