# The EBR-II X447 high-temperature U-10Zr metal alloy experiment

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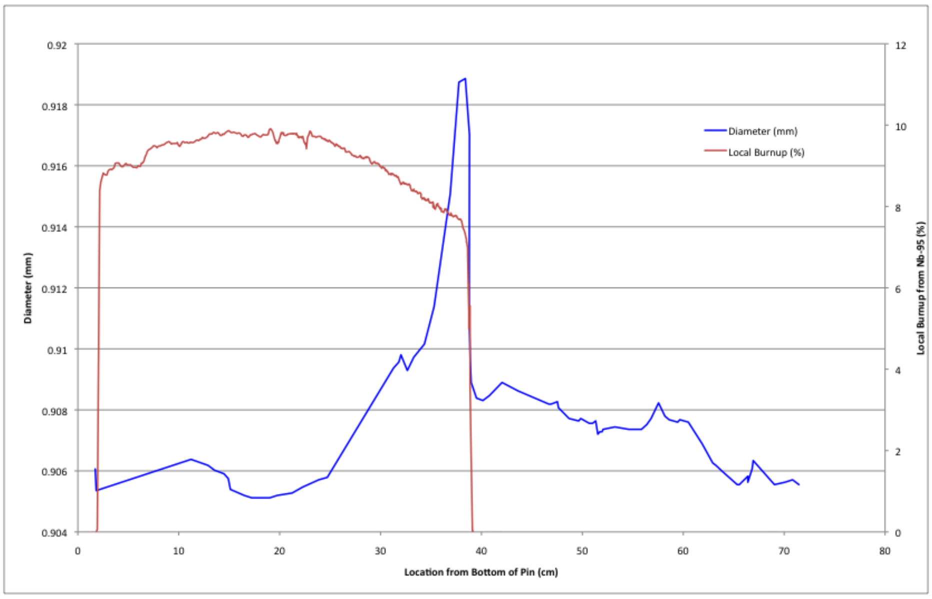
## Abstract

*The X447 experiment was conducted in the Experimental Breeder Reactor II (EBR-II) from 1988 through 1992 as part of the Integral Fast Reactor programme's development and testing of metallic fuel. The experiment was designed to operate at high temperature (630°C to 660°C PICT), near the 2-sigma operational limit for metallic fuel in EBR-II; at these temperatures, it was expected to undergo extensive fuel-cladding chemical interaction. The high cladding temperatures also provided a cladding lifetime test resulting in creep-rupture failure data on irradiated D9 and HT9 cladding. After achieving a burn-up of 5%, the subassembly was removed from the reactor and examined non-destructively. Reconstituted as X447A, it was reinserted into EBR-II and continued irradiation to 10% burn-up, at which time it was removed from the reactor following an indication of fuel pin failure in the X447 subassembly. The primary failure mechanism expected for these fuel pins was creep-rupture, accelerated by a cladding wall thinned by fuel cladding-chemical interaction. All fuel pins were intact when the subassembly was examined at ~5% burn-up. However, at approximately 10% burn-up, two fuel pins were breached. Six HT-9 clad fuel pins from the experiment were destructively examined, which included two pins at 4.7% burn-up and four pins at 10% burn-up. Two pins examined at the 10% burn-up level both showed extensive reaction between the U-10Zr fuel alloy and the HT9 cladding. A previous, preliminary analysis of the X447 experiment considered the possibility that fuel-cladding chemical interaction was accelerated post-breach due to fuel overheating as a result of partial venting of the bond sodium [1]. As an example of the fuel behaviour exhibited by pins in the X447 subassembly, Figure 1 shows axial burn-up compared to cladding dilation for an intact (DP-04) pin at 10% burn-up. Cladding dilation is extremely pronounced at the top of the fuel column, where cladding temperatures are at their peak values; this would be the location of maximum cladding creep, and could be the location of maximum fuel-cladding chemical interaction (if not rate-limited by fission product supply). Not surprisingly, this is the location of cladding breach in the two pins that experienced failure.*

*This paper explores the post-irradiation examination results in detail to in an attempt to gain a clear understanding of the behaviour and performance of the X447 experiment, especially focusing on the progression of fuel-clad chemical interaction, fuel constituent redistribution and cladding strain.*

**Figure 1: Comparison of cladding dilation with fuel column burn-up for X447 pin DP-04**

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## Reference

[1] Pahl, R.G., C.E. Lahm, S.L. Hayes, "Performance of HT9 Clad Metallic Fuel at High Temperature", *Journal of Nuclear Materials*, 204 (0), pp. 141-147 (1993).