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HIGH-RAMP-RATE TRANSIENT PERFORMANCE OF EBR-II METALLIC DRIVER FUEL

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The metallic driver fuel of EBR-II has just successfully undergone extensive repeated-power-transient testing. This was a major step in preparation for testing oxide fuel to 15% and 60% overpower conditions at power increase rates from 1 to 10% per second.

These most recent high-ramp-rate whole-core transients culminate qualification of the driver fuel which has included steady-state[1] and low-ramp-rate transient operation.[2] The next step will be in-core fuel-cladding penetration testing to verify the safety margin for anticipated and unlikely reactor transient events.

Five test assemblies containing driver fuel from 0 to 9.5 at.% burnup were irradiated under three peak cladding temperature (PCT) conditions: 600°C, nominal; 630°C, at the boundary of normal operation; and 660°C, at the boundary of operation with uncertainties. The elements in these tests were exposed to all combinations of irradiation conditions including steady-state, low-ramp-rate transient, and high-ramp rate transient. Selected elements also underwent temperature changes from 600 to 630 and back to 630°C PCT. The irradiation positions in the core ranged from row 2 to row 5. Most other experiments were removed from the reactor core for these transient tests.

The transients were initiated in early November 1982. After two trial transients to 50 and 56 MWt, the first power transient from 25 to 62.5 MWt in nine seconds was completed on November 4 by an automatic control rod which was computer controlled. Successive transients were then run every other day for a total of 13 full power transients. The power transient consisted of an up-ramp of 4 MWt/s from 25 to 62.5 MWt, a hold at 62.5 MWt for 12 minutes, and a down-ramp of about 3.7 MWt/s to 25 MWt.[3]

One of the test assemblies, XY-15, was positioned under the Fuel Performance Test Facility (FPTF). This facility provides measurement of assembly outlet temperature, coolant flow, and DN-detection. The assembly was orificed to obtain the highest PCT of 660°C and so flow control was not necessary. Figure 1 describes the power transient as measured by the temperature rise of the coolant exiting the XY-15 assembly. The measured outlet temperature did correspond to the 660°C PCT at the top of the fuel column. Passive temperature monitors dispersed throughout the assembly also verified the peak temperature.

The most important result of the transient test was that no cladding breaches were generated under these most demanding conditions. Preliminary tests and analyses predicted substantial stresses would be generated by fission gas pressure at high burnup, and by FCMI due to transient fuel swelling and phase transformation but that the combination of fuel creep and cladding strength would be sufficient to maintain integrity. In addition, a test conducted under FPTF just prior to the transient power tests demonstrated the reliability of high burnup fuel exposed to 66 temperature transients which simulated the power transients.

Secondly, postirradiation examination of the test elements has shown that there was no cladding diameter increase over that which has been observed for operation under steady-state conditions alone. The average peak diameter increase of many elements irradiated under steady-state and steady-state plus transient conditions over a wide range of burnup is shown in Fig. 2. Note that there is no significant difference in cladding strain indicating that transient operation generated immeasurable additional deformation. If there were little cladding ductility and thereby account for the minimal increase in strain, the fact that no cladding breaches were generated becomes even more significant.

Because of the satisfactory steady-state and transient performance and reliability of the EBR-II metallic driver fuel, the transient test program has now been successfully initiated.

References

1. B. R. Seidel and L. C. Walters, "EBR-II Metallic Driver Fuel - A Live Option," Journal of Engineering for Power, 103, 612 (1981).

2. J. A. Buzzell, et al., "Transient Performance of EBR-II Driver Fuel," Proceedings of ANS Topical on Reactor Safety Aspects of Fuel Behavior, 1, 415 (1981).

3. F. S. Kirn, "EBR-II Reactor Transient Qualification Tests," to be presented at the Eleventh Biennial Topical Meeting on Reactor Operating Experience, August 1-3, 1983, Scottsdale, Arizona.

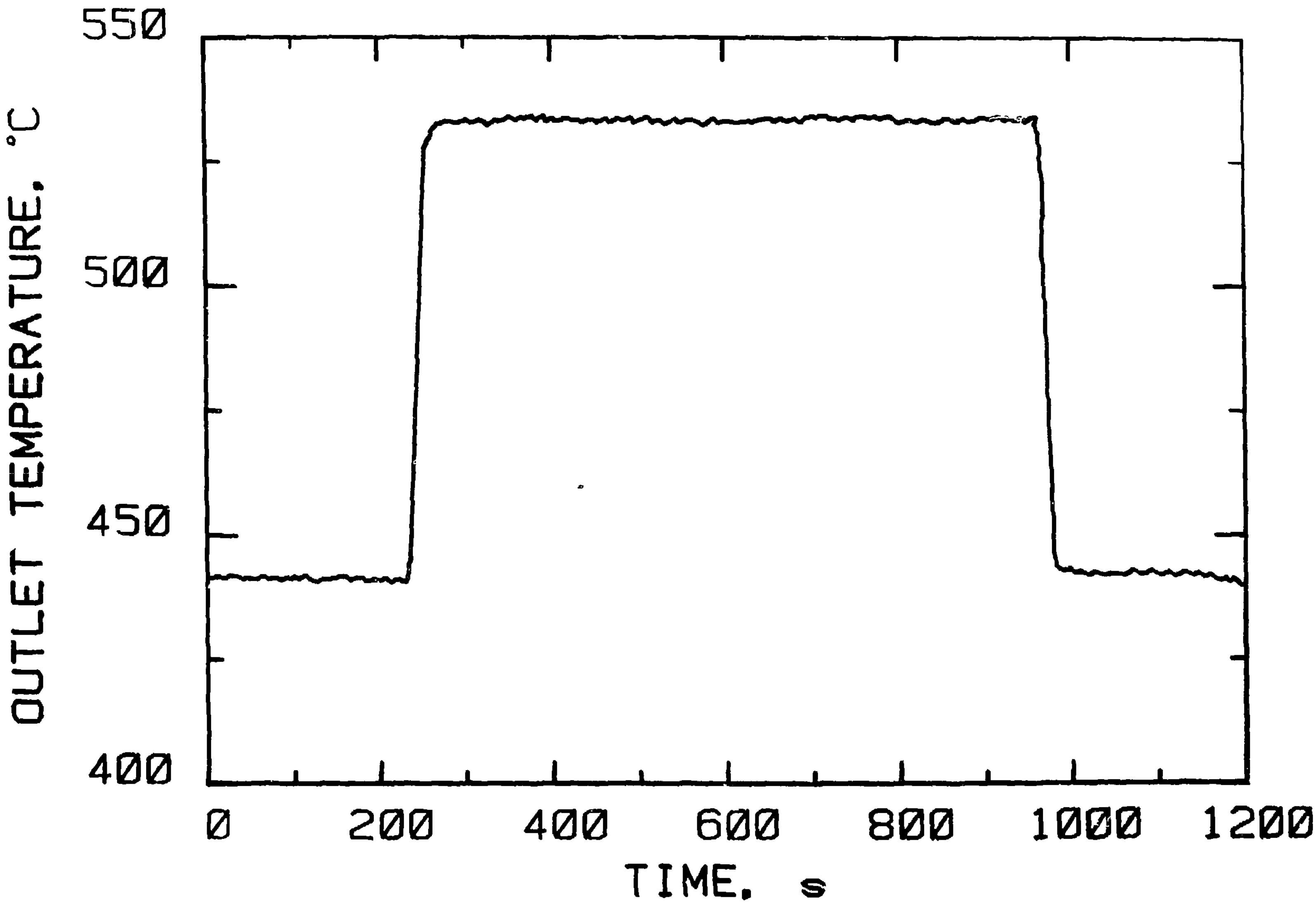

Figure 1. Measured Outlet Temperature of Transient Test Assembly XY-15 Under FPTF.

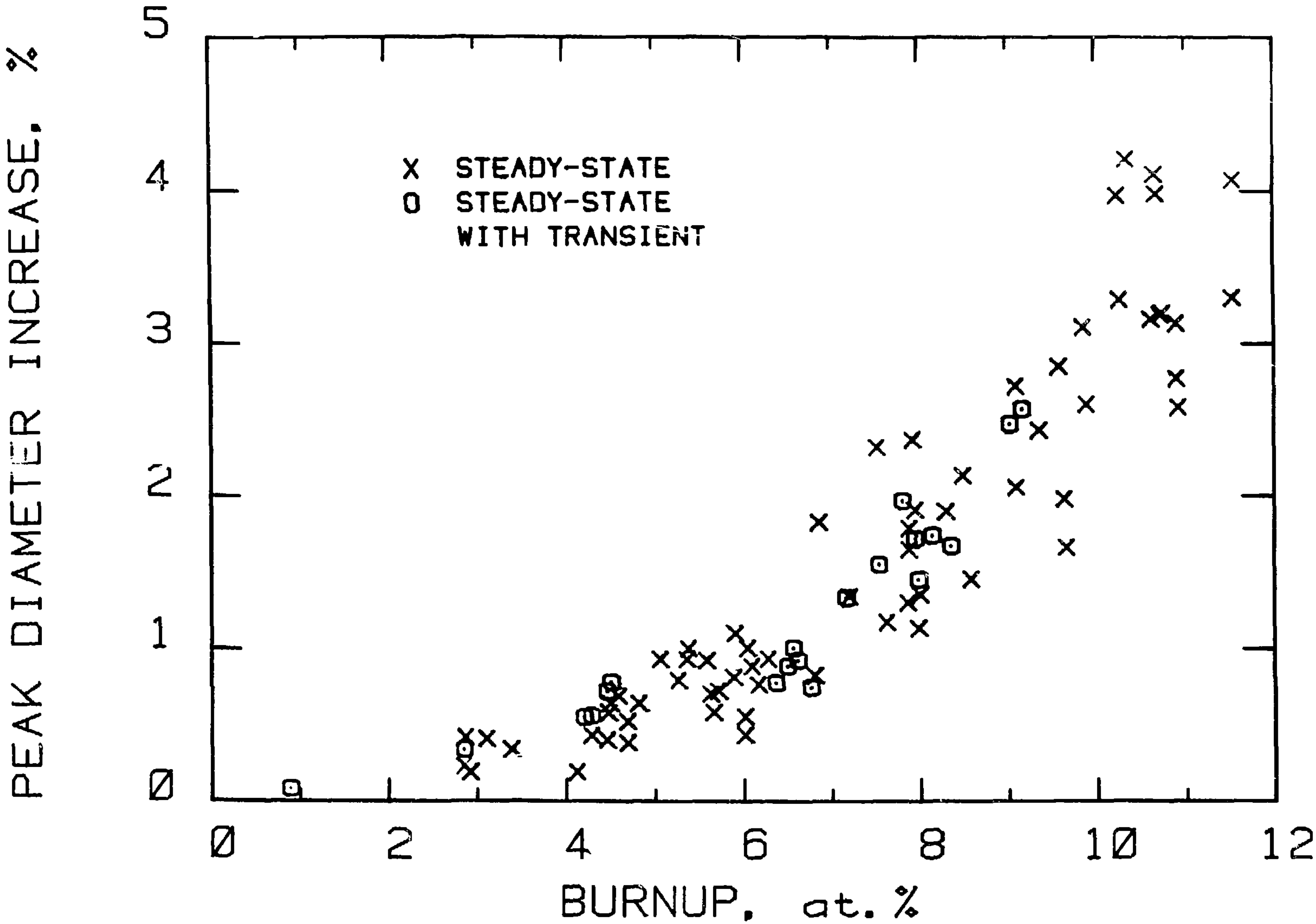

Figure 2. Comparison of Peak Element Diameter Increase (Averaged for Several Elements) Resulting from Steady-state Alone and Steady-state and Transient Operation.