CONF-830545--2

EXTENDED OVERPOWER TRANSIENT TESTING OF OXIDE PINS IN EBR-II*

by

H. Tsai and L. A. Neimark

Materials Science and Technology Division
ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

FINAL

CONF-830545--2

DE84 011743

April 1983

*Work supported by the U. S. Dept. of Energy.

To be presented at the Core Systems Working Group Information Meeting, May 10-12, 1983, Richland, WA.

EHB

EXTENDED OVERPOWER TRANSIENT TESTING OF OXIDE PINS IN EBR-II

H. Tsai and L. A. Neimark
Argonne National Laboratory

I. INTRODUCTION

Understanding of the behavior of oxide fuel and blanket pins during slow transients with ramps between 0.1 and 10%/s is of importance because of the higher likelihood of such operational transient events. Compared to faster transients for which a fair amount of knowledge exists through testing in TREAT, there is also some concern of whether the oxide pins are particularly vulnerable to slower transients. For these reasons, a cooperative program between the U.S. Department of Energy (DOE) and the Japanese Power Reactor and Nuclear Fuel Development Corporation (PNC) was launched to conduct operational transient testing (OTT) on oxide pins in EBR-II.

A total of eleven tests is included in this OTT program. The status of the five extended-overpower-transient tests on preirradiated EBR-II pins is the subject of this paper.

II. DESCRIPTION OF TESTS

The principal objectives of the extended overpower transient tests are:

(1) To establish breaching margins for irradiated oxide fuel and blanket pins above the plant-protection-system (PPS) thresholds over a range of ramp rates,

(2) To provide transient performance data for the validation of oxide pin behavior codes, e.g., LIFE-4,

(3) To establish a linkage between the EBR-II and TREAT transient data bases.

In EBR-II, overpower in test pins is achieved by moving the pins from an outer-row, lower flux steady-state position to the core center and ramping the reactor from a partial power to full power. To maximize the attainable overpower, pins previously irradiated in the outermost rows (i.e., Rows 5 and 6) are selected for these tests. With an EBR-II full power limit of 62.5 MWt, the attainable pin overpower at present is limited to ~60-70%. The 62.5 MWt limit may be waived for transient operations in the future and higher overpower may thus be possible for the latter tests in the series.

In addition to the slow ramp capability, EBR-II also has the advantage over TREAT, an adiabatic facility, of being able to provide an extensive preconditioning period prior to the overpower transient. The purpose of preconditioning is to re-establish the steady-state fuel microstructure, thus producing a prototypical mechanical balance between the fuel pellets and cladding. For slow transients in which fuel-cladding mechanical interaction is figured to play a prominant role for causing pin cladding damage, the ability to remove shut-down features in the fuel is considered to be quite important.

Of the five tests in the series, four tests, designated TOPI-1A, -1B, -1C, and -1D, are on fuel pins and one, TOPBI-1, is on blanket pins. Tests TOPI-1A and TOPBI-1 were conducted in February and the other three are in the planning stage.

A. Test TOPI-1A

Test TOPI-1A, consisting of 16 preirradiated P43 pins and 3 fresh P40 environmental pins, was the lead test in the series and attained a mean 60% overpower during a 0.1%/s ramp. The P43 pin complement had a range of burnup from 4 to 16 a/o and included types A, B, C, and F pins. (Type A was the FFTF reference fuel parameters, B and C were 91% smear density, and F was 89% smear density and D9 cladding). The pins were preconditioned for two days at 37.3 MWt, which corresponded to a nominal pin power of ~8 kW/ft, before being subjected to the overpower transient. The peak cladding ID temperature was ~1150 F during preconditioning and ~1400 F at the peak of the transient.

During the test, no delayed neutron (DN) or cover gas activities above the normal EBR-II background were detected. Postirradiation examination (PIE), which has just began, also confirmed that the subassembly contained no leakers. The test thus demonstrated oxide fuel pins with P43-type parameters are capable of withstanding a 60% overpower, 0.1%/s ramp without losing the cladding integrity. These positive results are significant in that they show, contrary to earlier LIFE-3 code predictions, irradiated oxide fuel pins do possess a significant cladding integrity margin over the PPS threshold (~15% overpower), at least at the ramp rate tested.

At the time of writing this paper, no futher PIE data is available.

B. Test TOPBI-1

Test TOPBI-1 was the parallel experiment to TOPI-1A on preirradiated oxide blanket pins. Seven WBA-21 and WBA-24 pins were included in the test. These pins had $(U,Pu)O_2$ pellets clad in 0.506-in OD, 15-mil thick type 316 first-core steel and had a smear density of ~94%. Four of the pins had WBA-21 steady-state irradiation only, two had only the WBA-24 (Run 112) transient irraidation and the remaining pin had both.

The transient conducted on the TOPBI-1 pins was a 0.1%/s ramp to 60% peak overpower preceded by a two-day preconditioning at the nominal pin power of ~14 kW/ft and peak cladding ID temperature of ~1150 F. Similar to the TOPI-1A fuel pin results, none of the blanket pins breached during the transient. Test TOPBI-1 thus demonstrated that at the 0.1%/s ramp rate, the blanket pins also possess a substantial cladding integrity margin over the PPS trip settings.

C. Tests TOPI-1B, -1C, -1D

These follow-on tests will be designed to explore overpower performance over a wide range of pin and test conditions, including: pin power, pin diameter, cladding temperature, cladding type, ramp rate, peak overpower and prior steady-state irradiation histories. The pin sources for these tests will include P43, P40, and the OTT TOP-4 and TOP-7 subassemblies. Planning of these tests is ongoing and will be evaluated against the TOPI-1A and TOPBI-1 PIE results as they become available. Steps that would enhance the probability of inducing cladding breaching, which is desirable for establishing cladding breaching criteria, are also being evaluated.

III. LIFE-4 CODE VALIDATION

Development of the LIFE-4 code is an integral part of the OTT program. While the code is used heavily for pretest planning, the tests are also expected to produce results that can be used as feedback to the code for enhancing its predictive capabilities. The test pin results suitable for code validation include cladding breaching threshold, transient cladding strain, fission gas release and fuel microstructural changes.

As the TOPI-1A and TOPBI-1 tests induced no cladding breaching, no breaching threshold data will be available for code validation at this time. Therefore, emphasis will be placed on the evaluation of transient-induced cladding strain and other tangible quantities. To this end, a large body of sibling information for the P43 and WBA-21/24 test pins is available for comparison purposes. Also, the strain profiles of the test pins were characterized in detail with the laser profilometer at HFEF prior to the transient, specifically for the purpose of providing data for accurate pre- and posttransient cladding strain comparisons.

The design of the follow-on tests will depend to a large extent on the PIE results of the TOPI-1A and TOPBI-1 tests. If necessary, the future tests will be designed more aggressively, while still maintaining the test conditions prototypical, to induce transient effects in the test pins for code validation.