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The PFR/TREAT Program

Objectives, Accomplishments, and Plans*

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Objectives

The PFR-TREAT collaborative program of transient safety testing of fast reactor fuel was established in 1979 to provide mutual advantage to USDOE and the UKAEA through irradiation of US and UK full-length fuel pins in PFR, followed by safety testing in TREAT. The tests which were planned include Transient Over-Power (TOP) and Transient Under-Cooling with Over-Power (TUCOP) tests to fuel destruction and re-distribution; the results will provide significant new information on fuel and cladding behavior in hypothetical reactor faults. The information obtained in both US and UK fuel pins is to be interpreted by both partners and published jointly when mutually agreed.

Significant Events

November 1979	Agreement signed
August 1980	Fresh UK pins shipped to USA
September 1980	Fresh US pins shipped to UK
November 1980	First test of fresh fuel in TREAT
February 1981	Irradiated UK pins shipped to USA (1st shipment)
August 1981	First US pins loaded into PFR

* Work performed under the auspices of the U. S. Department of Energy.

November 1981	First test of irradiated fuel
December 1981	Irradiated UK pins shipped to USA (2nd shipment)

Thirteen tests, on fresh and irradiated fuel, in single-pin and 7-pin test sections, were completed by the end of 1983. The test matrix, which is currently being re-evaluated, calls for additional tests to be run under the present agreement.

There has been an extensive program of post irradiation examination of sibling pins in both the UK and the US to characterize the test fuel prior to destructive irradiation, including testing of irradiated cladding to determine its failure characteristics.

In all of the tests the time and location of failure and the re-distribution of fuel has been monitored by the interpretation of loop instrumentation (thermocouples, flowmeters, pressure transducers) data and by the analysis of data from the fast neutron hodoscope. Details on the tests are given in other papers in this session. Also, one paper is concerned with some of the unique operations which were performed at TREAT as a part of this program and another is devoted to significant aspects of the fast neutron hodoscope analyses.

Important Observations on Completed Tests

A major overall observation is that in every test there has been an axial redistribution of fuel, which, in an actual fast reactor fault, would have a very significant effect in reducing reactivity and shutting down the core power. However, the 7-pin bundle tests have shown blockages of the coolant flow passages after this axial dispersion of fuel and cladding. This may be a small bundle effect; if it occurred in full scale sub-assemblies of a fast reactor, it may tend to inhibit in-situ cooling of the core after a major fault. In modelling fuel pin failure, it is clear that predictions of failure time and location using present methods are generally in good agreement with the experiments. The importance of cladding melt-through as a failure mechanism has been demonstrated and some progress has been made towards a better understanding of this phenomena. Some of the experiments have not achieved exactly the required conditions and have produced unexpected results, indicating that the failure of individual pins can be susceptible to changes in external heat transfer or pin internal geometry under special circumstances.

Fuel pin burnup does not appear to be a very important parameter. Four sets of closely similar tests, three (C01, C02 and C03; L01 and L02; C04 and C05) simulating TOP conditions and a fourth (L04, L06) simulating TUCOP conditions, with pin burnup the only major variable, have been run. Although the magnitude of the fuel motion appears to be a function of burnup, the trends in all cases are very similar. Further tests are needed to explore this point. If the initial indications are confirmed it would be possible to simplify reactor safety analysis considerably and to have greater confidence in the assessments.

The program has emphasized the need for good modelling of behavior in all stages of the experiments, through prediction of the pre-irradiation behavior to establish the pre-test condition of the fuel, -- in test rig design to allow for the non-prototypicalities in the coolant flow and nuclear heat generation pattern in the pins, -- and for interpretation after the test results are available.