The Axial Location of Cladding Failure During a Slow Transient Overpower TREAT Test

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The axial location of cladding failure following a transient overpower accident is of importance in fast reactor safety studies in that it is a determining factor in the relocation of fuel, and therefore in the possibility of inherent neutronic shutdown of the reactor. Cladding failure near the top of the active fuel is advantageous in that the ejected fuel is likely to be swept out of the core region by the coolant flow, thus providing negative reactivity. On the other hand, cladding failure near the axial midplane of the fuel implies the possibility of a positive reactivity insertion due to a locally increased fuel accumulation in the core.

In-pile experimental data on the axial location of cladding failure of fuel in bundles of pins is sparse since, in general, the experimental fuel pin bundles are largely destroyed during the in-pile test. Until recently, only three in-pile tests had post-test configurations which could be used to evaluate cladding failure. TREAT tests H5 and R12 indicated cladding failure at three-quarters height and at the top of the fuel column, respectively, and the SLSF ETR test W2 showed failure close to the midplane.

The post-test examination work has been completed for TREAT test J1. It was found that damage to the fuel elements during the irradiation was low enough for an accurate observation of the location of cladding failure to be made for each of the seven pins. J1 was a slow-period (10 s) TOP simulation using seven fuel pins pre-irradiated in EBR-II. A Mk-IIC loop with flowing sodium was used as the test vehicle. The TREAT power transient was terminated shortly after a signal indicating that cladding failure had occurred was received. This enabled the fuel pin bundle to be preserved in much the same configuration as existed when cladding failure first occurred. Further details of the J1 test can be found in ref. 1.

The J1 test train contained a cluster of seven preirradiated fuel pins with a 343 mm (13 1/2 in.) mixed-oxide fuel column. Six peripheral pins were symmetrically spaced around a center pin. For purposes of orientation the peripheral pin nearest the pump, looking down on the cluster, was described as at 12 o'clock. The other peripheral elements were at 2, 4, 6, 8 and 10 o'clock.

Post-test examination showed that three of the seven pins failed. All the fuel columns except the one nearest the pump (12 o'clock) showed some axial expansion, and the six peripheral pins all showed considerable melted fuel. The fuel in the center pin may have had some local melted areas.

The expanded lengths of the fuel column clockwise from the pump were 0, 3, 13, 32, 37 and 13 mm. The center pin expanded about 2 mm. Pairs of fuel columns at 4 and 10 o'clock and 6 and 8 o'clock showed similar expansions.

The fuel pins at 2, 4 and 6 o'clock failed. The failures started at the tops of the fuel columns and extended upward along the insulator pellets for a total length of about 20 mm. Cladding failures tended to be toward the outside of the cluster with a bias toward an adjacent pin. The fuel expelled from one pin may have contributed toward failure of an adjacent element. The fuel expelled from the three failed elements was not enough to make a significant blockage to coolant flow.

Failures appeared to be associated with a local condition on one side of the cluster. The failure did not seem to be directly associated with the extent of melting, axial expansion of the fuel column, or the location of the spacer wires.

The axial and circumferential locations of cladding failure are showed schematically in Fig. 1. Also shown are the locations of fuel pellets and insulator pellets, indicating the extent of fuel expansion. Fig. 2 is a cross-section of the fuel pin bundle about 10 mm above the top of the original active fuel column.

Reference 1. R. J. Page et al. "Results from the J1 low ramp rate TREAT experiment", Trans. Am. Nucl. Soc., 34, 545 (1980).

J1

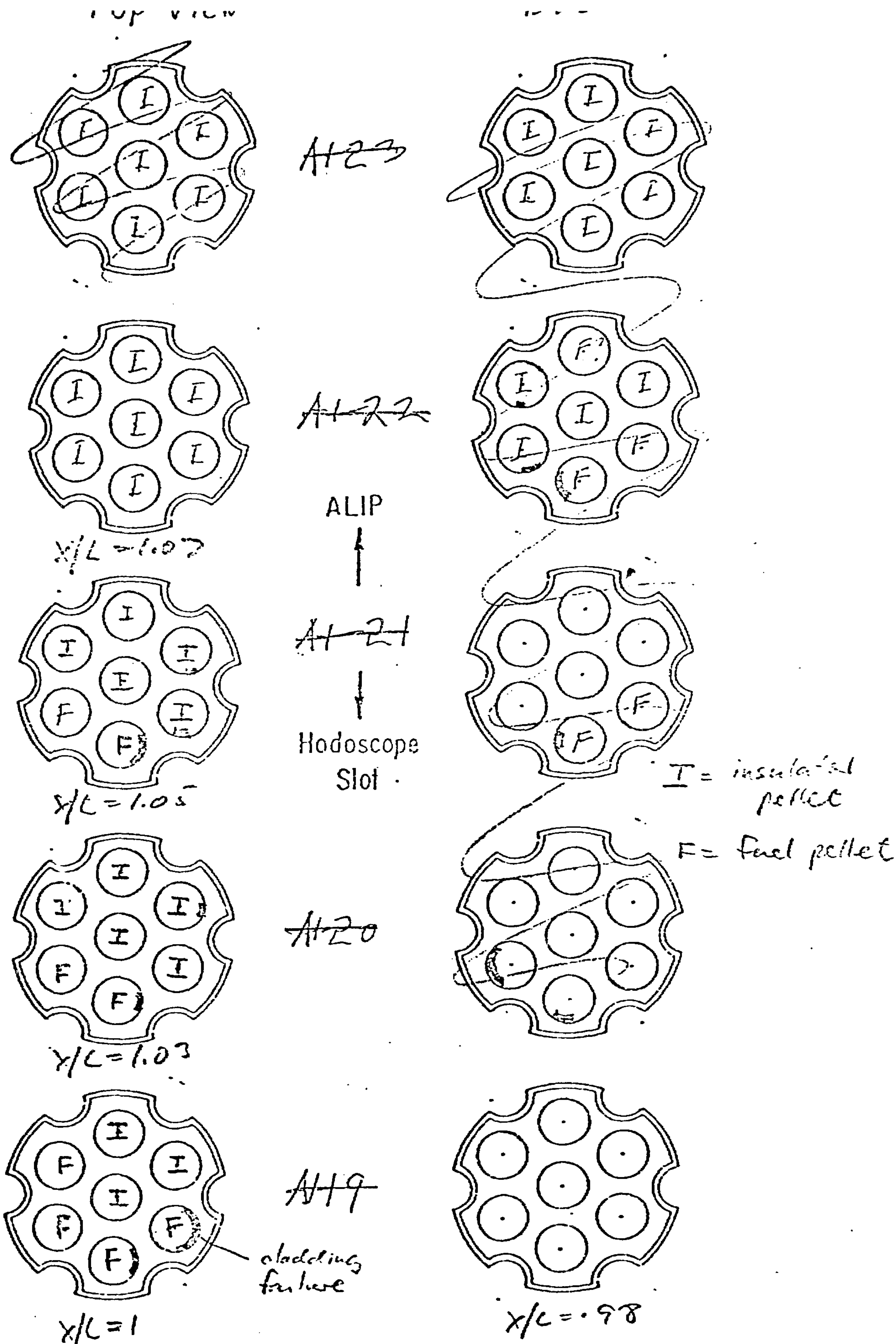

Fig 1 Cladding failure locations for the J1 test.

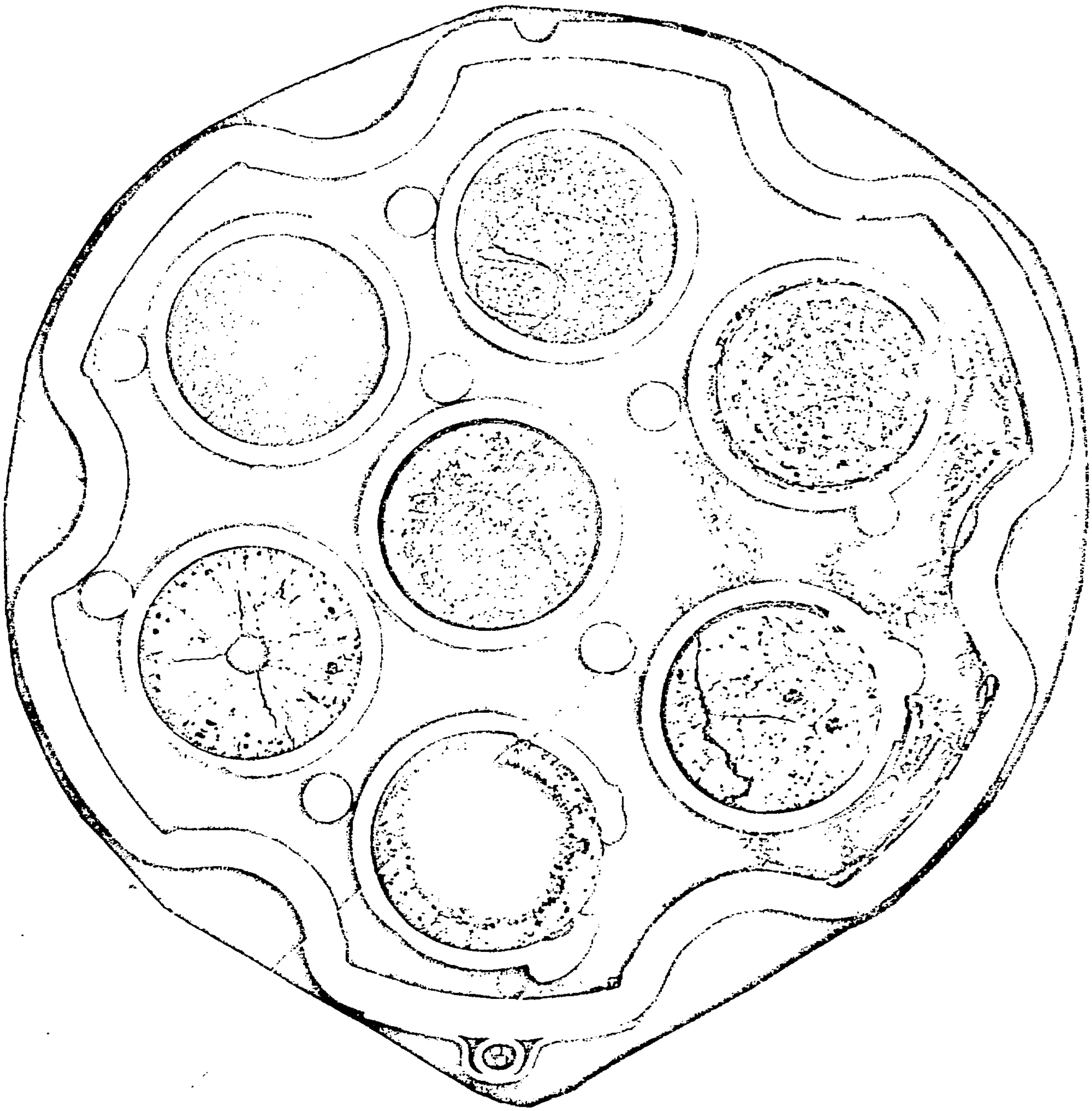

Fig 2. Cross-section of J1 fuel pin bundle at X/L = 1.03.