**FLOW EXCURSION TIME SCALES IN THE
ADVANCED NEUTRON SOURCE REACTOR***

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ABSTRACT

The Advanced Neutron Source (ANS) reactor is currently being designed to provide the world's highest steady-state thermal neutron flux for scattering experiments. As a result, the ANS reactor core must cope with both high heat flux levels and extremely concentrated power densities. The present core design uses aluminum-clad fuel plates packed in an involute geometry to form parallel flow channels between the upper and lower plenums. To achieve the desired power densities, a channel gap of only 1.27 mm is planned, together with a 507 mm heated length and nominal coolant velocity of 25 m/s. The nominal average and peak heat fluxes are approximately 6 and 12 MW/m², respectively. Such a parallel-plate core is particularly vulnerable to fuel damage resulting from excursive flow instability, and one can envision certain accident scenarios in which the thermal limits set by flow excursion correlations might be exceeded for brief intervals. A key objective of this paper is to determine how long a flow excursion transient takes to bring about a system failure under ANS conditions.

The anticipated time scale of flow excursions in the ANS has been examined by subdividing the transient into its component phenomena. Once conditions necessary to initiate an excursion failure are present, vapor bubble nucleation and growth to detachment size must take place. Depending on the surface characteristics of the ANS fuel plates, the creation of vapor bubbles may also be delayed by the need to form a metastable, superheated liquid prior to nucleation. Then the resulting two-phase flow has to be decelerated against the fluid's inertia until a critical heat flux (CHF) condition occurs. Finally, the thermal inertia of the ANS fuel plates themselves must be taken into account to see how much time elapses between a CHF film-boiling condition and the onset of fuel melting. Models have been developed to estimate the time required for each of these individual stages. The time actually spent in an unstable flow regime begins when the system rounds the minimum of the channel demand curve and continues until fuel melting occurs due to departure from nucleate boiling.

Both declining core flow and core exit depressurization scenarios have been examined, with all calculations starting from full ANS power levels. The first case corresponds to a flow excursion generated by movement down the channel demand curve to the minimum point, while the second simulates an excursion resulting from an upward shift of the demand curve at lower pressures. A computer solution of the momentum equation by Runge-Kutta integration was used to investigate the excursion time scale

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resulting from overcoming fluid inertia to slow the coolant flow. In these calculations, the Saha-Zuber correlation was invoked to determine the onset of significant voiding and initiation of two-phase flow. The predicted fluid inertia delays for flow excursions in the ANS were generally in the millisecond range, with exit depressurization transients taking somewhat less time than those involving reduced flow. For either transient, the bubble growth times to detachment proved to be on the order of microseconds. Thermal inertia effects were most evident in reduced flow transients while the influence of a metastable liquid phase was largely confined to depressurization cases. However neither effect added appreciably to the fluid inertia delay times. Comparisons of the overall flow excursion times to RELAP5 models are made for both transient situations. Hopefully, these results will lead to increased understanding of flow excursion transients and how they would progress during accident scenarios in the ANS reactor.