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APPLICATION OF SSC-L TO INVESTIGATE NATURAL CONVECTION IN DAMAGED LMFBR CORES

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SUMMARY

APPLICATION OF SSC-L TO INVESTIGATE* NATURAL CONVECTION IN DAMAGED LMFBR CORES

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The loop version of the Super System Code (SSC-L)[1,2] is utilized to study the response of a system representation of the CRBRP to various degrees of assumed damage postulated to occur in single fuel assemblies and groups of fuel assemblies under coast down to natural convection operation. The damage imposed is measured in terms of instantaneous increases to the fuel assembly nominal pressure drop (ΔP_A). Damage factors for ΔP_A of 1.0, 1.88, 3.0 and 4.0 were applied to average fuel channels in groups of one, seven and forty-two assemblies.

Using the SSC-L code, damage to fuel assemblies can be assumed to occur in various ways: (1) blockages at the assembly inlet orifice zone, (2) blockages through the heated zone via fuel swelling, bowing, etc.; or (3) blockages at the assembly outlet. The detailed responses of the flow rates and temperatures of the affected assemblies to these blockages do depend on the actual blockage location, but these influences of blockage location on the peak core assembly temperatures attained will be shown to be minor and can be considered as second-order effects.

For the purposes here, the postulated blockages are assumed to occur within the heated zone of the fuel assemblies. Both the extent of the blockage within an individual assembly and the number of fueled assemblies damaged within the core are investigated. To provide a normalized method of comparison, the extent of damage to an assembly is quantified by the amount of damage required to instantaneously raise the total assembly pressure drop (ΔP_A) by

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No. of Assemblies Damaged	Peak Temperature (K)			
	$\Delta P_A \times 1.0$	$\Delta P_A \times 1.88$	$\Delta P_A \times 3.0$	$\Delta P_A \times 4.0$
1	912	1010	1115	1184
7	912	1009	1113	1181
42	912	1002	1103	1167

Table 1. Peak Coolant Temperatures Attained in Damaged Fuel Assemblies During LOEP Event

assembly flow rates. Typical of this type of natural convection transient, the lower flow rate produces not only higher temperatures, but also delays the time at which the second peak occurs (from 160 seconds for no damage case, out to 300 seconds for $\Delta P_A \times 4.0$ case).

The transient system response for the other damage cases studied (groups of 1 damaged assembly and 42 damaged assemblies) are quite similar. The peak maximum temperatures attained are summarized in Table 1. As noted, even for cases where the assumed damage caused the initial ΔP_A to be increased by a factor of 4.0, the sodium in the affected average fuel channel did not reach saturation temperature.

Table 1 also indicates another interesting result. For cases where the assumed damage to the individual assemblies is identical, the peak temperature attained decreases as more assemblies are involved. This would not be entirely obvious at first glance since competing factors influence this response. Namely: (1) increasing the number of assemblies assumed damaged leads to higher overall resistance and consequently lower loop and total vessel flow available; (2) as more assemblies are damaged, a higher percentage of the core

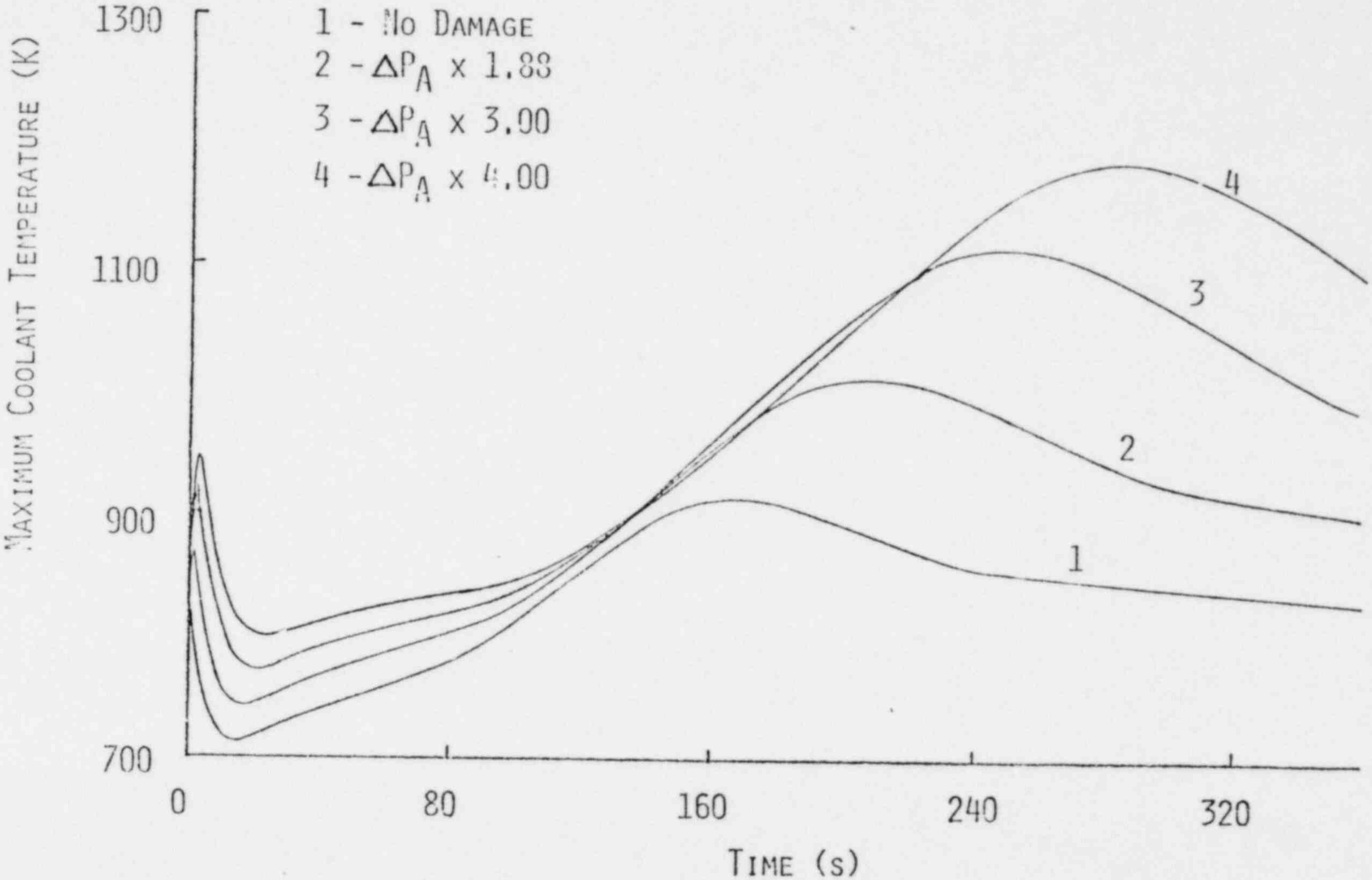

FIGURE 1 RESPONSE OF MAXIMUM COOLANT TEMPERATURE IN AVERAGE FUEL CHANNEL (CLUSTER OF SEVEN ASSEMBLIES) TO AN LOEP EVENT WITH ASSUMED DAMAGE

will be at elevated temperatures, which means, due to bouyancy driven flow redistribution effects, that more flow will redistribute in a relative sense to the damaged assemblies; and (3) since all assemblies are forced by design to have identical pressure drops, momentum and continuity relationships dictate that involving more assemblies in the damage will lead those assemblies to obtain a higher percentage of the total flow available. The results of this study show for the cases analyzed, that the combined effect of the second and third influences dominate over the first, such that the peak temperature attained decreases when the number of identical assemblies assumed damaged is increased. These results also emphasize the fact that the use of an analytical tool such as SSC-L, which can simultaneously account for the complex inter-coupling of the many competing physical phenomena modeled is essential to properly calculate transients of this nature.

In summary, damage factors for ΔP_A of 1.0, 1.88, 3.0 and 4.0 were applied to average fuel channels in groups of one, seven and forty-two assemblies. A factor for ΔP_A for an average fuel assembly of greater than four was found necessary to cause sodium boiling under coast down to natural convection conditions. Due to the inter-coupling of several physical phenomena properly modeled within the SSC-L code, increasing the number of average fuel assemblies assumed to be damaged led to a decreasing peak maximum coolant temperature attained. For the cases analyzed here, SSC-L typically computed the simulated transient on a CDC 7600 in a machine time faster than real time[4].

REFERENCES

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