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**EFFLUENT VERSUS INLET HEADER BREAK ANALYSIS FOR  
SRS-REACTOR LOPA SCENARIO (U)**

by

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**EFFLUENT VERSUS INLET HEADER BREAK ANALYSIS  
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**INTRODUCTION**

The Loss-of-Pumping Accident (LOPA) is a design basis accident for the Savannah River Site (SRS) reactors. The LOPA is defined as a Double Ended Guillotine Break (DEGB) in a secondary cooling water pipe. The secondary cooling line break is termed inlet or effluent depending on break location. Upon break detection emergency shut down procedure begins, the reactor scrams, secondary cooling pump motors trip off, primary cooling pump AC motors switch off, and DC motor drive engages. Secondary cooling gravity flow continues flooding the building after secondary cooling pumps are off. The Emergency Cooling System (ECS) activates before the DC motors flood out. Break detection time, header flooding rate, and flooding locations are different for the inlet and effluent header breaks due to different break locations. Inlet and effluent header break primary coolant temperature transients differ because primary and secondary cooling pumps continue during a break detection and reactor scram time delay for the effluent header case, whereas the pumps trip off almost immediately for the inlet header case. Design basis accident reactor core power limits are calculated for both the inlet and effluent header breaks.

## DESCRIPTION

The accident scenario is constructed with regard to physical, mechanical, and human factors for both inlet and effluent header break cases. The inlet header break is postulated in one of two heat exchanger secondary cooling inlet headers which cannot be isolated. Inlet header break is detected instantaneously via inlet header pressure loss, and the reactor scram signal is sent within one second. The coupled secondary and primary coolant pumps trip off within three seconds. One-half of all heat exchangers lose secondary cooling immediately upon header break. The effluent header break is postulated in one of two heat exchanger secondary cooling effluent headers. The effluent header break is detected after 100 seconds by motor room sump flooding, and the reactor scram signal is delayed 25 seconds. The primary and secondary coolant pumps trip off at 126 seconds. Secondary cooling increases for those 126 seconds and then reduces for gravity flow.

In the inlet header case the broken header secondary flow floods the motor room for three seconds followed by continuous gravity flow flooding. The motor room water level reaches alarm set point in four minutes, and the operator receives DC Motors Flood Out Imminent Alarm. The operator has one minute to activate Emergency Cooling System manually. The DC motors flood out six minutes after break initiation.

For the effluent header case the cooling water first floods the pump room, overflows a dam, and then floods the motor room. The secondary flow increases in both inlet headers, resulting in greater core cooling during the 125 second period before reactor scram. The broken header flow increase is greater than the unbroken header. The effluent header leak rate is greater than the inlet header leak rate due to backflow and a greater contribution from the intact header. The operator receives DC Motors Flood Out Imminent Alarm in about seven minutes. The effluent header break imminent alarm takes longer because this break floods more building area before reaching the motor room alarm set point. The time intervals between ECS actuation and DC motors flood out are 76 and 48 seconds for the inlet and effluent cases. Time intervals from reactor scram to DC

motors flood out are 428 and 448 seconds. Table 1 presents the simulated events sequence for the inlet and effluent header break scenarios.

The accident scenarios are simulated using system code TRAC. The assembly analyses are performed with SRS assembly code FLOWTRAN. The detailed calculational procedures are described in References 1, 2, and 3. Figure 1 shows the broken side assembly inlet temperature and relative deposited power for the inlet and effluent header break cases. Increased cooling from more secondary water flow decreases assembly inlet temperature, decreasing average reactor core temperature. Lower core temperature increases core power due to negative temperature reactivity coefficients. This increase in power stabilizes at approximately 5.5% by reactor scram time.

## RESULTS

The inlet header break steady state phase (full primary and secondary flow) limit is almost identical to the effluent header break steady state phase. For the effluent header case the assembly inlet temperature drops over 1 C from its steady state value while the assembly experiences 5.5% deposited power increase by scram time. The inlet temperature drop cancels out the power increase as both header break assembly effluent temperatures remain basically the same during the steady state phase. After reactor scram and before DC motors flood out, the effluent header case inlet temperatures are lower due to increased secondary cooling. The inlet header break is more limiting than the effluent break for this transient phase, but this phase is not the overall limiting phase. The ECS phase is the limiting phase for both header breaks, and the inlet header break limit is slightly lower than the effluent header. The difference between the two cases derives from differences in pre-ECS core temperatures and simulated ECS flows. Deposited power fractions are about equal at the times when ECS limits are set. Since analyses demonstrate that the inlet header break is more limiting for all phases, future limit analysis will concentrate solely on the inlet header break.

## REFERENCES

1. P. K. PAUL, K. L. BARBOUR, "Loss of Pumping Accident Limit Calculation for Savannah River Reactor," to appear in *Trans. Am. Nucl. Soc.*, (June 1992).
2. P. K. PAUL et al., "Power Limits Methodology for the Mark 22 Loss of Pumping Accident (LOPA)," Westinghouse Savannah River Company Report, WSRC-RP-91-443, Revision 1 (1992).
3. P. K. PAUL, K. L. BARBOUR, "DEGB LOPA Limit Recommendation for the K-14.1 Subcycle," Westinghouse Savannah River Company Report, WSRC-RP-91-444, Revision 1 (1992).

**Table 1**  
**Break Scenarios**

<u>Event</u>	<u>Time (seconds)</u>	
	<b>Inlet</b>	<b>Effluent</b>
. Inlet header pipe break	0	0
Break detected	0	100
. Scram signal sent	1	125
. AC motors and 190 Bldg. pumps trip off	3.00	126
. Pump motor room water level reaches alarm set point	237	411
. ECS actuated by the operator	297	471
. Circuitry delay (1 second)	298	472
. Booster and ECS pump start (actual)	298	472
. Booster and ECS pumps run-up (29 seconds delay)	327	501
. ECS valves begin to open in TRAC model	327	501
. ECS valves are fully open in TRAC model (1 second)	328	502
. DC motors flood out	373	519
. Circuitry Delay (1 second)	374	520
. Rotovalves begin to close	374	520
. Rotovalves fully closed (15 seconds)	389	535
. DC motors coast down to 2.5% flow	428	572
. Ramp DC flow to zero	429	573

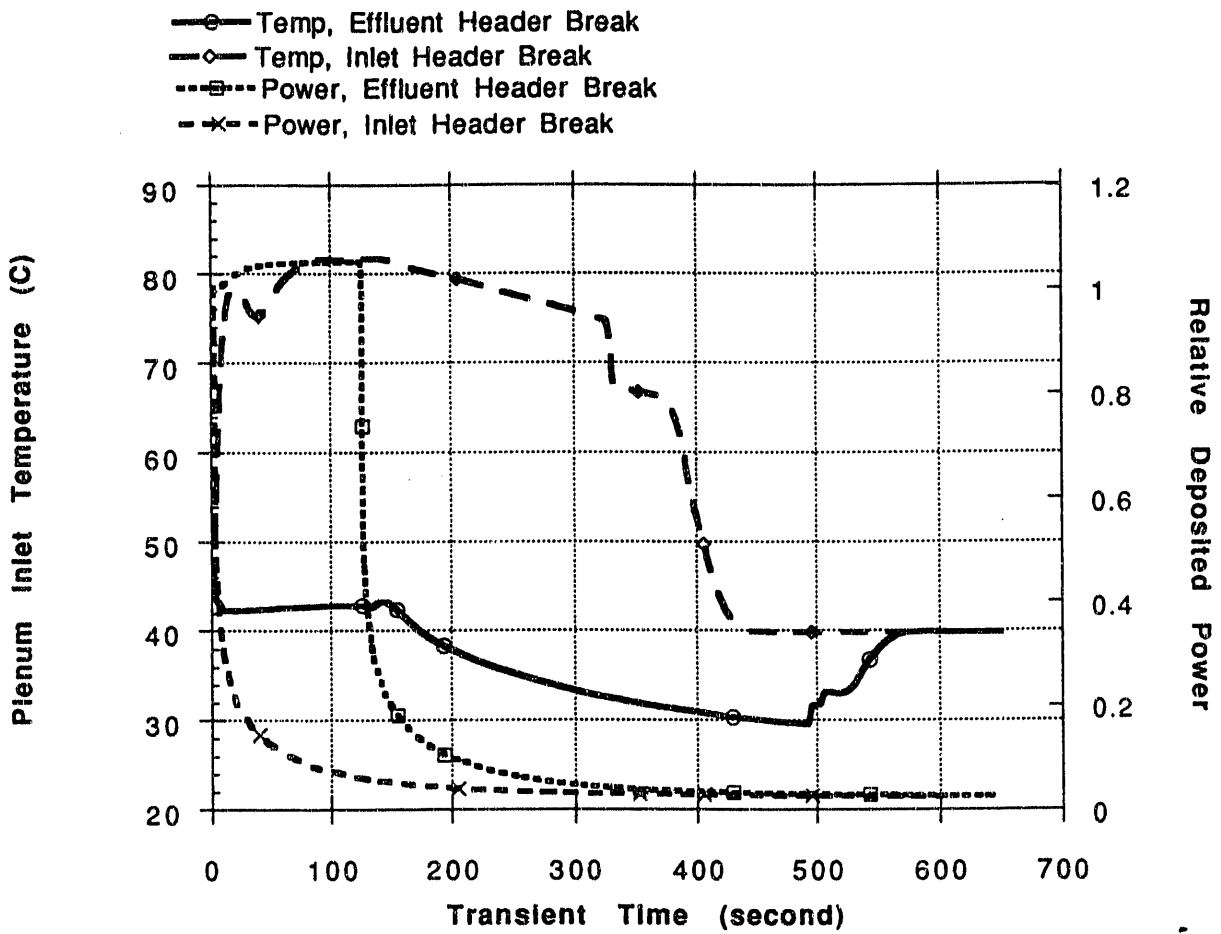


Figure 1. Inlet Temperature and Deposited Power Profiles

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