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CODE DEVELOPMENT-VERIFICATION-APPLICATION

# REACTOR BEHAVIOR PROGRAM

SYSTEMS ANALYSIS-DATA ANALYSIS

PLUGGED STEAM GENERATOR EFFECTS  
ON A LOCA

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## SUMMARY

This report documents and details the results of a study of the effects of partially plugged steam generators in a large pressurized water reactor (PWR) undergoing a postulated loss-of-coolant accident (LOCA). The study not only treats various degrees of steam generator tube plugging, but also includes both symmetric and asymmetric type plugging. The analysis examines the LOCA through the blowdown, refill, and reflood regions of the accident and includes a hot pin heatup calculation to determine the peak cladding temperature for each steam generator tube plugging case studied.

The LOCA chosen is a postulated 200% double-ended cold leg guillotine break. This postulated accident is generally regarded as the worst-case accident in a large PWR and is thus best suited for this evaluation model (EM) licensing type analysis. The plant used in the study is the Zion I reactor, a 15 x 15 type fuel element four loop PWR designed by Westinghouse Electric Corporation.

The analysis was carried out in four separate phases for each steam generator tube plugging case studied. First, the blowdown portion of the postulated LOCA was evaluated using the RELAP4/MOD5-EM computer code and carried to end-of-bypass (EOB). Next, the refill time was computed to determine the time at which core reflooding would begin and a TOODEE2 hot pin analysis was performed. The TOODEE2 code is used to predict the hot pin thermal and mechanical response during the refill period, utilizing EOB information from the RELAP4/MOD5-EM analysis and assuming an adiabatic core heatup during refill. The third step was to incorporate the RELAP4/MOD5-EM and TOODEE2 adiabatic heatup results as input to the RELAP4/MOD5-FLOOD computer code to determine the core reflooding rate in order to analyze the reflood portion of the transient. Finally, the results of the first three calculations were used as input to a second TOODEE2 hot pin calculation which was evaluated through the reflood regime of the LOCA to determine the maximum hot spot cladding temperature.

1765 157

The cases of steam generator tube plugging to be addressed in the study are:

- (1) Base case (all loops unperturbed)
- (2) 10% flow blockage in the broken loop steam generator (asymmetric)
- (3) 25% flow blockage in the broken loop steam generator (asymmetric)
- (4) 25% flow blockage in a single intact loop steam generator (asymmetric)
- (5) 10% flow blockage in all steam generators (symmetric)
- (6) 25% flow blockage in all steam generators (symmetric).

The study results indicated some very definite trends. Table I shows the effect of plugged steam generators on some of the major LOCA events and Figure 1 illustrates the effect of steam generator tube plugging on peak clad temperature.

The maximum effect on peak cladding temperature was observed to occur for the 25% symmetric steam generator tube blockage where an increase of 50 K with respect to the base case results was calculated. The single intact loop (asymmetric) tube plugging case yielded the same results as an equivalent amount of symmetric tube plugging. The broken loop tube plugging cases resulted in a negligible ( $<0.5$  K) effect on the predicted maximum peak cladding temperature.

1765 158

TABLE I

EFFECT OF STEAM GENERATOR TUBE PLUGGING ON A POSTULATED LOCA  
(200% Double-Ended Cold Leg Guillotine Break)

Case	Time of EOB <sup>[a]</sup> (s)	Cladding Rupture Predicted <sup>[a,b]</sup> (s)	Time for Start of Reflood <sup>[a]</sup> (s)	Peak Cladding Temperature Reached <sup>[a]</sup> (s)	Peak Cladding Temperature <sup>[c]</sup>			
					At EOB (K)	At Start of Reflood (K)	For LOCA (K)	
Base	30.1	39.7	45.2	167.9	1041.2	1228.9	1448.8	2148
Broken Loop								
10%	30.0	39.7	45.1	167.8	1040.9	1227.3	1449.1	2149
25%	30.2	40.0	45.3	165.8	1040.0	1224.9	1448.5	2148
Intact Loop								
25%	29.9	38.4	45.0	168.3	1054.5	1246.5	1450.7	2168
All Loops								
10%	29.7	38.0	44.8	166.6	1059.8	1255.0	1467.7	2148
25%	28.6	36.0	43.7	170.3	1072.9	1278.7	1497.7	2245

[a] All times based on time of break.  
 [b] All ruptures occurred at the 1.9-m elevation.  
 [c] All peaks occurred at the 2.4-m elevation.

1765 159

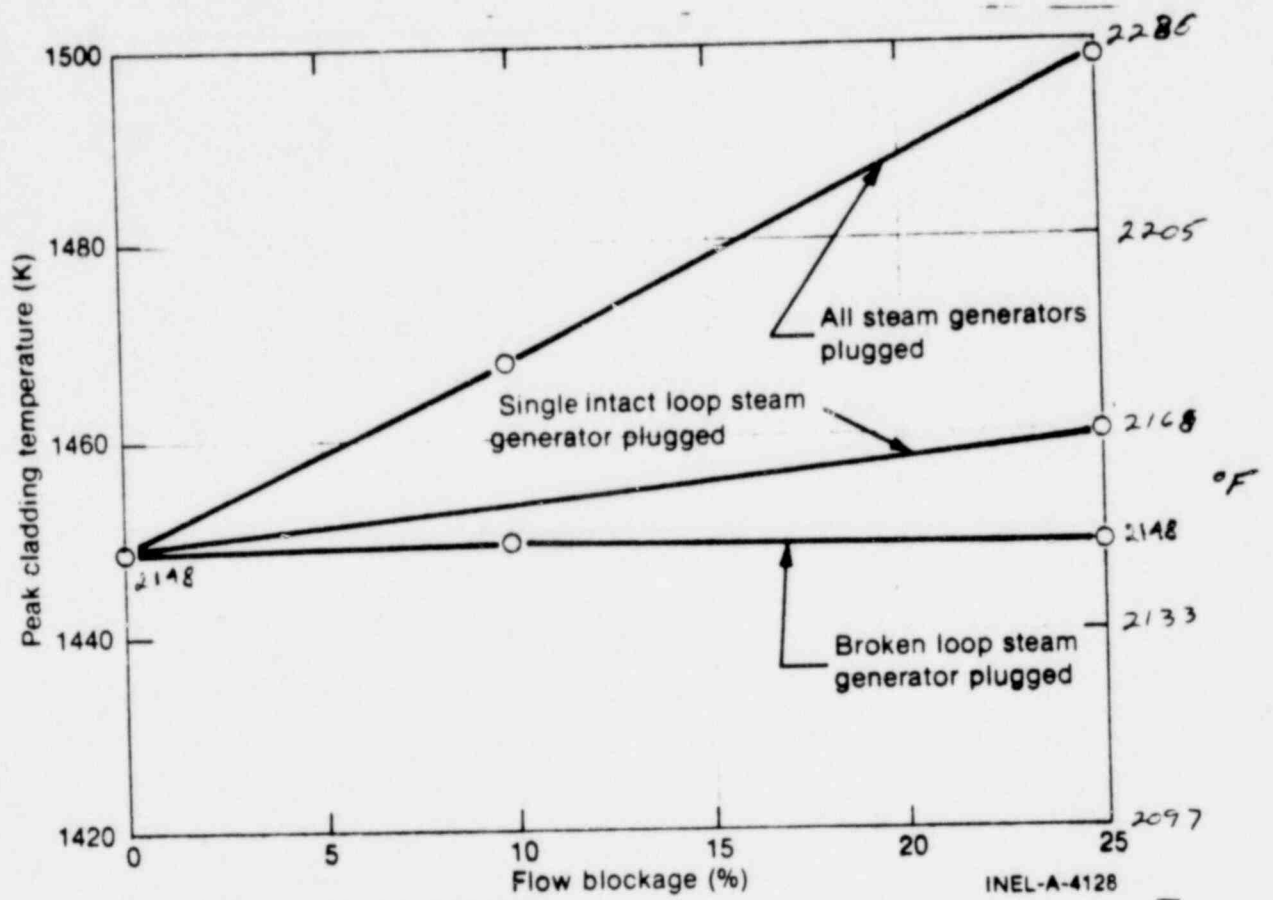


Fig. 1 Effect of steam generator tube plugging on peak cladding surface temperature.

1765 160