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RTR-2431 DELETED VERSION

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SUBCYCLE-SPECIFIC EMERGENCY COOLING LIMITS

INTRODUCTION

Assembly power limits are prescribed for each reactor charge so that the Emergency Cooling System (ECS) will prevent core damage from exceeding specified damage limits during a postulated loss-of-coolant (LOCA) or loss-of-pumping (LOPA) accident. Core damage limits are given in Technical Standard 3.02 (Reference 1). Generic assembly power limits which include a 10% uncertainty factor have been determined (Reference 2) for the Mark 16B-31 charge. However, future power limits will not be based on the Reference 2 values because a new damage model is being developed. These limits can be determined at present if the minimum assembly flows during a LOCA are known.

SUMMARY

Minimum assembly flows for the K-12.6, P-9.3, P-9.4, L-2.1 and L-2.2 subcycles were determined to provide input for the new damage models currently being developed by SRL. Table 1 lists these flows, which were calculated from the FLOOD84 computer code (Reference 4).

DISCUSSION

Background

Reference 3 published generic ECS-LOCA power limits for Mark 31A assemblies in PKL reactors. However, these limits were obtained using specific damage models which overestimated the power being supplied to the coolant channel.

A new ECS damage model is currently under development. Because the upcoming reactor subcycles will use this model, minimum assembly flows during LOCA conditions are needed for the new model to predict an ECS limit. These flows can be determined from the FLOOD84 computer code.

Analysis

Subcycle-specific assembly power limits and flows are generated by executing the FLOOD84 code which models the reactor flow configuration during a design basis LOCA. The necessary records and procedure for executing the FLOOD84 code are discussed in Reference 5. The minimum assembly flows calculated by FLOOD84 are dependent upon the amount of emergency cooling water (ECW) that is supplied to the plenum (Reference 6) and the specific subcycle flow control components. To provide a conservative margin on the power limits, ECS flow rates are reduced by the applicable uncertainty (Reference 7) attributed to the measured flows. Table 2 shows the ECS flows for the design basis LOCA with the flow uncertainty applied for three different ECS pump source cases. These cases include (1) the booster pump operable with [redacted] flow, (2) the booster pump operable flow, and (3) the booster pump inoperable or [redacted] flow. The flows for the booster pump operable plus [redacted] case, as determined from the PIPEFLOW code, are 5% higher than those for only the booster pump.

Once the minimum assembly flows are calculated by FLOOD84, they will be entered into the improved LOCA damage models currently being developed. After the emergency cooling limits are generated, they will be implemented as assembly-average effluent temperature limits identical to the method used in implementing confinement protection assembly power limits.

Results

The K-12.6, L-2.1, L-2.2, P-9.3, and P-9.4 subcycles have been analyzed with the FLOOD84 code. Minimum assembly flows for the various assembly types, hardware configurations, and booster pump operability are shown in Table 1. In comparison, the current generic assembly power limits were calculated using an assembly flow of 8.95 gpm and an ECS flow of 5085 gpm through only one ECS addition path for the booster pump operable case. Correspondingly, the booster pump inoperable case used an assembly flow of 8.25 gpm and an ECS flowrate of 4650 gpm. Both cases assume that 6 DC driven pumps are operating.

The subcycle-specific power limits will use the minimum assembly flows calculated by FLOOD84 and the specific ECS flowrate with applicable uncertainty found in Table 2. For example, the inoperable booster pump case was generated for the K-12.6 subcycle using an ECS flow of 5107 gpm. The FLOOD84 results show significant increases in the minimum assembly flows when compared with the generic flows. These flows will then be entered into the improved LOCA damage models currently being developed by SRL.

REFERENCES

1. DPSTM-105, 105-Building Technical Standards, 3.02, "Reactor Emergency Cooling System", April 4, 1977.

2. J. P. Church & J. L. Steimke, Revised Emergency Cooling System LOCA Limits for PKL-Reactor Mark 16B-31 Charges, DPST-86-699, October 2, 1986.

3. D. A. Crowley, Interim Emergency Cooling System Limits for PKL-Reactor Mark 16B-31 Charges, DPST-85-946, October 21, 1985.

4. J. P. Church, Computer Program for Calculating Equilibrium Flows and Reactor Damage with Reduced Cooling, DPSTM-130, July 16, 1985.

5. M. J. Giess, Subcycle-Specific ECS Power Limits, Inter-Office Memorandum, October 29, 1986.

6. J. H. Hinton, Emergency Cooling System Flows, RTR-2239, March 13, 1985.

7. J. E. McAllister, Uncertainty Analysis of Emergency Cooling System Flows, RTR-2341, January 27, 1986.

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TABLE 1

MINIMUM ASSEMBLY FLOWS DURING DESIGN BASIS LOCA

Subcycle: K-12.6

Assembly	Number of Orifice Holes	Minimum Assembly Flows, GPM Pump Sources		
		Booster Pump [redacted]	Booster Pump	[redacted]
Mk 16B	Unorificed	Not calculated	10.8	10.3
Mk 31A	Unorificed		10.8	10.3
	36		N/A	N/A
	18		N/A	N/A
Mk 31B	Unorificed		17.1	16.3
	36		18.5	17.6
	18		30.8	29.7

TABLE 1 (Cont.)

MINIMUM ASSEMBLY FLOWS DURING DESIGN BASIS LOCA

Subcycle: P-9.3

Assembly	Number of Orifice Holes	Minimum Assembly Flows, GPM — Pump Sources		
		Booster Pump [redacted]	Booster Pump	[redacted]
Mk 16B	Unorificed	10.0	9.4	9.1
Mk 31A	Unorificed	N/A	N/A	N/A
	36	10.0	9.4	9.1
	18	30.2	28.5	27.5
Mk 31B	Unorificed	N/A	N/A	N/A
	36	N/A	N/A	N/A
	18	N/A	N/A	N/A

Subcycle: P-9.4

Assembly	Number of Orifice Holes	Minimum Assembly Flows, GPM — Pump Sources		
		Booster Pump [redacted]	Booster Pump	[redacted]
Mk 16B	Unorificed	9.9	9.4	9.0
Mk 31A	Unorificed	N/A	N/A	N/A
	36	9.9	9.4	9.1
	18	30.6	28.7	27.7
Mk 31B	Unorificed	N/A	N/A	N/A
	36	N/A	N/A	N/A
	18	N/A	N/A	N/A

TABLE 1 (Cont.)

MINIMUM ASSEMBLY FLOWS DURING DESIGN BASIS LOCA

Subcycle: L-2.1

Assembly	Number of Orifice Holes	Minimum Assembly Flows, GPM		
		Pump Sources		
		Booster Pump [redacted]	Booster Pump	[redacted]
Mk 16B	Unorificed	11.2	10.5	10.0
Mk 31A	Unorificed	11.2	10.5	10.0
	36	22.8	19.8	18.7
	18	33.9	31.7	30.0
Mk 31B	Unorificed	N/A	N/A	N/A
	36	N/A	N/A	N/A
	18	N/A	N/A	N/A

Subcycle: L-2.2

Assembly	Number of Orifice Holes	Minimum Assembly Flows, GPM		
		Pump Sources		
		Booster Pump [redacted]	Booster Pump	[redacted]
Mk 16B	Unorificed	11.0	10.4	9.9
Mk 31A	Unorificed	N/A	N/A	N/A
	36	11.0	10.4	9.9
	18	33.5	31.4	29.8
Mk 31B	Unorificed	N/A	N/A	N/A
	36	N/A	N/A	N/A
	18	N/A	N/A	N/A

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TABLE 2

CALCULATED ECS FLOWS FOR LOCA

Emergency Cooling System On	With Leak	Booster Pump, [redacted] and [redacted] Flow (GPM) P	LK	% Uncertainty
[redacted]	[redacted]	5437	5650	3.4
		5200	5587	2.9
		Booster Pump Flow (GPM)		
		5178	5381	3.4
		4952	5321	2.9
		[redacted] Flow (GPM)		
		4892	5221	3.5
		4806	5107	2.9

Note: All flows include applicable uncertainty.