

## New Transient Analysis Results 160226

I need to show that the fuel cladding safety limit of 530 C is not reached under the following conditions:

- Natural Convection Cooling Under Steady State Power Conditions
- Forced Convection Cooling Under Steady State Power Conditions
- Natural Convection Cooling Under Transient Power Conditions
- Forced Convection Cooling Under Transient Power Conditions

### Natural Convection Cooling Under Steady State Power Conditions

The analysis for this condition is described in the memo entitled “Steady State Thermal Hydraulic Analysis for Natural Convective Flow in the Rhode Island Nuclear Science Center (RINSC) Reactor”. Section 4.7.6 shows the results of the analysis to be that for the most limiting fuel plate to reach the onset of nucleate boiling under natural convection flow conditions with 130 F water, at a height of 23 ft 6.5 in above the active core, reactor power would have to be 369 kW.

Based on this analysis, and the measurement error that has been determined, the proposed Technical Specification limiting safety system settings are:

Natural Convection Steady State Analysis							
Parameter	Limiting True Value		Measurement	Minimum		Proposed TS LSSS	
	Used in Analysis		Error	LSSS		TS 2.2.1	
P		369 kW	10 kW		359 kW		P measured
	to reach ONB						115 kW
H	23 ft	6.5 in	0.5 in	23 ft	7 in	23 ft	7 in
	Above Fuel Meat						
T pool		130 F	3 F		127 F		127 F

### Forced Convection Cooling Under Steady State Power Conditions

The analysis for this condition is described in the memo entitled “Steady State Thermal Hydraulic Analysis for Forced Convective Flow in the Rhode Island Nuclear Science Center (RINSC) Reactor”. Section 4.6.10 shows the results of the analysis to be that for the most limiting fuel plate to reach the onset of nucleate boiling under flow conditions 1580 gpm with 120 F water, at a height of 23 ft 6.5 in above the active core, reactor power would have to be 4.72 MW.

Forced Convection Steady State Analysis							
Parameter	Limiting True Value		Measurement	Minimum		Proposed LSSS	
	Used in Analysis		Error	LSSS		TS 2.2.2	
P		4.72 MW	0.2 MW		4.52 MW		P measured
		to reach ONB					2.3 MW
H	23 ft	6.5 in	0.5 in	23 ft	7 in	23 ft	7 in
		Above Fuel Meat					
m		1580 gpm	60 gpm		1640 gpm		1600 gpm
		1500 gpm			1560 gpm		1560 gpm
T out		125 F	3 F		128 F		121 F
		To Have T channel					
		Average = 120 F					
		Not Used					None
T in		115 F	3 F		112 F		None
		To Have T channel					
		Average = 120 F					
		125 F			122 F		122 F

The transient analyses were done in response to RAI Question 13.7. The parameter settings that were used for the transient analyses, the measurement error associated with each parameter, and the minimum LSSS for each parameter are:

Analysis Settings							
Parameter	Limiting True Value		Measurement	Minimum		Proposed LSSS	
	Used in Analysis		Error	LSSS		TS 2.2.2	
P	P trip =	2.5 MW	0.2 MW	P trip =	2.3 MW		P measured
							2.3 MW
H	23 ft	6.5 in	0.5 in	23 ft	7 in	23 ft	8.4 in
		Above Fuel Meat					
m		1500 gpm	60 gpm		1560 gpm		1600 gpm
T in		125 F	3 F		122 F		122 F
T out		None					None

Five transients were considered:

- Case 1: Rapid Insertion of 0.6%  $\Delta k/k$  Reactivity From Very Low Power
- Case 2: Slow Insertion of 0.02 %  $\Delta k/k$  /Second Reactivity From Very Low Power
- Case 3: Slow Insertion of 0.02 %  $\Delta k/k$  / Second Reactivity From 1.8 MW Power
- Case 4: Slow Insertion of 0.02 %  $\Delta k/k$  /second Reactivity From 2.2 MW Power
- Case 5: Rapid Insertion of 0.6%  $\Delta k/k$  Reactivity From 100 kW Under Natural Convection Cooling

A summary of the results for each case is:

Forced Convection Transient Analysis - Case 1									
Transient	P i = 10 W and 0.6%dk/k is added over a period of 0.1 s. Reactor trips at P = 2.5 MW.								
Description	100 ms delay before negative reactivity inserted. P max = 2.61 MW.								
Parameter	Limiting True Value			Measurement Error	Minimum LSSS		Proposed LSSS		
	Used in Analysis				LSSS		TS 2.2.2		
P	P i	=	10 W	0.2 MW	P trip	=	2.3 MW	P measured	2.3 MW
	P trip	=	2.5 MW						
	P max	=	2.61 MW						
H	23 ft	6.5 in	0.5 in	23 ft	7 in	23 ft	7 in		
	Above Fuel Meat								
m		1500 gpm	60 gpm		1560 gpm		1560 gpm		
T in		125 F	3 F		122 F		122 F		
T out	Not Used						None		
Transient Results	Maximum Centerline T fuel meat			Maximum T clad surface	Maximum T coolant				
	87.1 C			86.2 C	68.0 C				

Forced Convection Transient Analysis - Case 2									
Transient	P i = 10 W and 0.02 %dk/k per second is inserted for 100s. Reactor trips at P = 2.5 MW.								
Description	100 ms delay before negative reactivity inserted. P max = 2.69 MW.								
Parameter	Limiting True Value			Measurement Error	Minimum LSSS		Proposed LSSS		
	Used in Analysis				LSSS		TS 2.2.2		
P	P i	=	10 W	0.2 MW	P trip	=	2.3 MW	P measured	2.3 MW
	P trip	=	2.5 MW						
	P max	=	2.69 MW						
H	23 ft	6.5 in	0.5 in	23 ft	7 in	23 ft	7 in		
	Above Fuel Meat								
m		1500 gpm	60 gpm		1560 gpm		1560 gpm		
T in		125 F	3 F		122 F		122 F		
T out	Not Used						None		
Transient Results	Maximum Centerline T fuel meat			Maximum T clad surface	Maximum T coolant				
	86.1 C			85.2 C	67.0 C				

Forced Convection Transient Analysis - Case 3									
Transient Description	P i = 1.8 MW and 0.02 %dk/k per second is inserted for 100s. Reactor trips at P = 2.5 MW. 100 ms delay before negative reactivity inserted. P max = 2.516 MW.								
Parameter	Limiting True Value Used in Analysis			Measurement Error	Minimum LSSS			Proposed LSSS TS 2.2.2	
P	P i	=	1.8 MW	0.2 MW	P trip	=	2.3 MW	P measured	
	P trip	=	2.5 MW				2.3 MW		
	P max	=	2.516 MW						
H	23 ft	6.5 in		0.5 in	23 ft	7 in	23 ft	7 in	
	Above Fuel Meat								
m			1500 gpm	60 gpm			1560 gpm		1560 gpm
T in			125 F	3 F			122 F		122 F
T out	Not Used							None	
Transient Results	Maximum Centerline T fuel meat			Maximum T clad surface	Maximum T coolant				
	88.6 C			87.8 C	69.6 C				

Forced Convection Transient Analysis - Case 4									
Transient Description	P i = 2.2 MW and 0.02 %dk/k per second is inserted for 100s. Reactor trips at P = 2.5 MW. 100 ms delay before negative reactivity inserted. P max = 2.5112 MW.								
Parameter	Limiting True Value Used in Analysis			Measurement Error	Minimum LSSS			Proposed LSSS TS 2.2.2	
P	P i	=	2.2 MW	0.2 MW	P trip	=	2.3 MW	P measured	
	P trip	=	2.5 MW				2.3 MW		
	P max	=	2.511 MW						
H	23 ft	6.5 in		0.5 in	23 ft	7 in	23 ft	7 in	
	Above Fuel Meat								
m			1500 gpm	60 gpm			1560 gpm		1560 gpm
T in			125 F	3 F			122 F		122 F
T out	Not Used							None	
Transient Results	Maximum Centerline T fuel meat			Maximum T clad surface	Maximum T coolant				
	88.8 C			87.9 C	69.6 C				

Natural Convection Transient Analysis - Case 5									
Transient Description	P i = 100 kW which is allowed to stabilize for 360 S. 0.6% dk/k is inserted over a time period of 0.1 s. Reactor trips at 125 kW. P max reaches 369 kW.								
Parameter	Limiting True Value Used in Analysis			Measurement Error	Minimum LSSS			Proposed LSSS TS 2.2.1	
P	P i	=	100 kW	10 kW	P trip	=	115 kW	P measured	
	P trip	=	125 kW			115 kW			
	P max	=	369 kW						
H	23 ft		6.5 in	0.5 in	23 ft		7 in	23 ft	7 in
	Above Fuel Meat								
T pool			130 F	3 F			127 F		127 F
Transient Results	Maximum Centerline T fuel meat			Maximum T clad surface	Maximum T coolant				
	78.9 C			78.9 C	75.7 C				