VIRGINIA ELECTRIC AND POWER COMPANY
RICHMOND, VIRGINIA 23261

March 30, 2006

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D.C. 20555

Serial No. 06-142
NL&OS/ETS R0
Docket Nos. 50-338/339
License Nos. NPF-4/7

**VIRGINIA ELECTRIC AND POWER COMPANY (DOMINION)
NORTH ANNA POWER STATION UNIT NOS. 1 AND 2
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION ON PROPOSED TECHNICAL SPECIFICATION CHANGES ON ADDITION OF ANALYTICAL METHODOLOGY TO THE CORE OPERATING LIMITS REPORT (TAC NOS. MC7526 AND MC7527)**

By letter dated July 5, 2005 (Serial No. 05-419), Dominion submitted proposed license amendments for North Anna Units Nos. 1 and 2. The proposed changes would add a reference in Technical Specification 5.6.5.b, "Core Operating Limits Report (COLR), to allow the use of an alternate methodology to perform a thermal-hydraulics analysis to predict the critical heat flux and departure from nucleate boiling ratio (DNBR) for the Advanced Mark-BW fuel. In addition, Dominion requested the Nuclear Regulatory Commission (NRC) staff's approval of the site/fuel type/code specific Statistical Design Limits obtained by the plant specific implementation of the NRC-approved methodology documented in Topical Report VEP-NE-2-A, "Statistical DNBR Evaluation Methodology." In a letter dated February 14, 2006, the NRC staff requested additional information to complete the review. The attachment to this letter provides the requested information.

Dominion continues to request approval of this license amendment request by September 1, 2006. This requested schedule permits in-house performance of DNB analyses with DOM-NAF-2 and the VIPRE-D/BWU code/correlation set in support of the use of AREVA AMBW fuel at North Anna Power Station Units 1 and 2 for operating cycles 20 and 19, respectively. This change will be implemented within 60 days of NRC approval.

If you have any questions or require additional information, please contact Mr. Thomas Shaub at (804) 273-2763.

Very truly yours,

William R. Matthews
Senior Vice President – Nuclear Operations

Attachment

Commitments made in this letter: None

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COMMONWEALTH OF VIRGINIA)
)
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The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by William R. Matthews, who is Senior Vice President – Nuclear Operations, of Virginia Electric and Power Company. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 30th day of March, 2006.

My Commission Expires: August 31, 2008.

Margaret B. Bennett
Notary Public

(SEAL)

ATTACHMENT

Serial No. 06-142

Response to Request for Additional Information on Proposed Technical Specification Changes on Addition of Analytical Methodology to the Core Operating Limits Report
(Tac Nos. MC7526 and MC7527)

Virginia Electric and Power Company
(Dominion)
North Anna Power Station Units 1 and 2

Virginia Electric and Power Company (Dominion)
North Anna Power Station Unit Nos. 1 and 2
Response to Request for Additional Information on Proposed Technical Specification Changes on Addition of Analytical Methodology to the Core Operating Limits Report (Tac Nos. MC7526 And MC7527)

Background

"By letter dated July 5, 2005, Virginia Electric and Power Company (VEPCO) submitted proposed license amendments to add a reference in Technical Specification 5.6.5.b, "Core Operating Limits Report (COLR)," to permit the use of an alternate methodology to perform a thermal-hydraulic analysis to predict the critical heat flux (CHF) and departure from nucleate boiling (DNB) ratio (DNBR) for the Advanced Mark-BW (AMBW) fuel at North Anna Power Station, Unit Nos. 1 and 2 (North Anna 1 and 2). Within 45 days of the date of the letter, VEPCO is requested to respond to the following questions below."

NRC Question

1. *Table 3.1.2-1 lists the uncertainties, probability distributions, nominal values and standard deviation of statistically treated parameters. These uncertainties and distributions deviate somewhat from that listed in Table 4.2-1 in Attachment 6 to Dominion Letter Serial No. 02-167 (L. N. Hartz to NRC, dated March 28, 2002).*

   Provide the analyses performed to derive the uncertainty values and distributions of each of these parameters. The uncertainty analysis description should include, as appropriate, a block diagram depicting sensor, processing equipment, computer, and readout devices for each parameter channel. Within each element of the block diagram identify the accuracy, drift, range, span, operating limits, and setpoints. Identify the overall accuracy of each channel transmitter to final output and specify the minimum acceptable accuracy for use with the determination of the statistical design limit (SDL).

Dominion Response

Consistent with the Statistical DNBR Evaluation Methodology topical report [Reference 2], inlet temperature, pressurizer pressure, core thermal power, and vessel flow rate were selected as statistically treated parameters in the implementation analysis. The magnitudes and functional forms of the uncertainties for the statistically treated parameters were derived in a rigorous analysis of North Anna plant hardware and measurement/calibration procedures, and were summarized in Table 3.1.2-1 of Reference 1. Bounding values for the uncertainties were then assumed in the implementation analyses of the Statistical DNBR Evaluation Methodology to cover potential plant changes.

As noted by the NRC in their letter dated February 14, 2006 [Reference 6], the values for these uncertainties and distributions are different from those reported in Table 4.2-1 in

Attachment 6 to the Dominion letter dated March 28, 2002 (Serial No. 02-167) [Reference 4]. There are two reasons for these differences. First, the channel statistical accuracies for plant parameters evolve over time due to changes in instrumentation and calibration procedures. These changes are tracked via the station design control processes. Hence, it is important to use bounding values for the uncertainties in the process to cover potential plant changes. The discussion which follows provides the current assessment of the uncertainties.

The second reason for the differences is directly related to the transition to AREVA fuel. Reference 4 submitted the analyses to support the transition from the Westinghouse fuel product to the AREVA Advanced Mark-BW fuel product. Those analyses relied upon NRC-approved methodologies developed by AREVA. Consequently, although the uncertainties for the inlet temperature, pressurizer pressure and vessel flow rate were quantified to be normal, two-sided, 95% probability distributions, the uncertainty distributions for these parameters in Reference 4 were assumed to be uniformly distributed in accordance with the AREVA Statistical Core Design for Mixing Vane Cores topical report [Reference 5]. In contrast, these variables are treated with normal distributions in the Dominion Statistical DNBR Evaluation Methodology [Reference 2].

Methodology

The methodology used to combine the error components for a channel is the appropriate statistical combination of those groups of components which are statistically independent, i.e., not interactive. Those errors that are interactive are added arithmetically into groups to form independent groups that can be statistically combined. Systematic (bias) errors are combined arithmetically outside the radical. This methodology for the combination of uncertainties is termed the "Square Root of the Sum of the Squares" (SRSS). The calculation for the total statistical error allowance for a loop calibration by modules with systematic error(s) is defined as follows:

$$CSA = SE \pm [EA^2 + PMA^2 + PEA^2 + (SCA + SMTE)^2 + SD^2 + SPE^2 + STE^2$$
$$+ (M1 + M1MTE)^2 + (M2 + M2MTE)^2 + \quad + (Mn + MnMTE)^2 + RD^2 + RTE^2 + RRA^2]^{1/2}$$

where:

CSA	=	Channel Statistical Accuracy
SE	=	Systematic Error; i.e., error due to environmental conditions
EA	=	Environmental Allowance
PMA	=	Process Measurement Accuracy
PEA	=	Primary Element Accuracy
SCA	=	Sensor Calibration Accuracy
SMTE	=	Sensor Measuring and Test Equipment
SD	=	Sensor Drift

SPE	=	Sensor Pressure Effect
STE	=	Sensor Temperature Effect
SPSE	=	Sensor Power Supply Effect
M1	=	First Module Accuracy
M1MTE	=	First Module Measurement and Test Equipment Accuracy
M2	=	Second Module Accuracy
M2MTE	=	Second Rack Measurement and Test Equipment Accuracy
Mn	=	nth Module Accuracy
MnMTE	=	nth Rack Measurement and Test Equipment Accuracy
RD	=	Rack Drift
RTE	=	Rack Temperature Effects
RRA	=	Rack Readability Allowance

Pressurizer Pressure

Dominion has quantified the magnitude and distribution of uncertainty on the pressurizer pressure (system pressure) per the pressurizer pressure control system. Figure 1-1 provides a simplified schematic of the pressurizer pressure control system. The current component accuracies for the pressurizer pressure control loop are shown in Table 1-1. In Reference 1, the pressurizer pressure uncertainty was quantified as a normal, two-sided, 95% probability distribution with a magnitude of ± 3.30% of an 800 psi span or ± 26.4 psi. Subsequent to our submittal, the calculation was revised to reflect the inclusion of a revised STE (increase from 0.713% to 1.425%) for the pressure transmitter to reflect a wider variation in containment ambient temperature. The pressurizer pressure uncertainty is presently quantified as a normal, two-sided, 95% probability distribution with a magnitude of ± 3.55% of an 800 psi span or ± 28.4 psi.

The pressurizer pressure uncertainty was conservatively applied in Reference 1 as a normal, two-sided, 95% probability distribution with a magnitude of ± 30 psia and a standard deviation (σ) of 15.306 psia. This assumed uncertainty represents the minimum required accuracy for the pressurizer pressure and bounds the quantified uncertainty.

Average Temperature

Dominion has quantified the magnitude and distribution of uncertainty on the average temperature (Tavg) per the Tavg rod control system. Figure 1-2 provides a simplified schematic of the Tavg rod control system. The current component accuracies for the Tavg rod control loop are shown in Table 1-2. In Reference 1, the average temperature uncertainty was quantified as a normal, two-sided, 95% probability distribution with a magnitude of ± 3.26% of span or ±3.26°F. Subsequent to our submittal, the calculation was revised to reflect a change in the accuracy of RTD amplifiers from 0.6% to 0.5%. The average temperature uncertainty is presently quantified as a normal, two-sided, 95% probability distribution with a magnitude of ± 3.25% of span or ±3.25°F.

The average temperature uncertainty was conservatively applied in Reference 1 as a normal, two-sided, 95% probability distribution with a magnitude of ± 4.2°F and a standard deviation (σ) of 2.143°F. This assumed uncertainty represents the minimum required accuracy for Tavg and bounds the quantified uncertainty.

Core Power

Dominion has quantified the uncertainty on core power as measured by the secondary side heat balance. The inputs to the secondary side heat balance calculation are from feedwater temperature, steam pressure, feedwater flow differential pressure, moisture carryover, and the feedwater venturi flow coefficient.

The overall uncertainty is calculated as follows. First, uncertainties on core power due to feedwater temperature, steam pressure, and feedwater flow differential pressure are determined on a loop basis. These uncertainties are combined to provide a loop power uncertainty. In the next step, the uncertainties on core power due to moisture carryover and feedwater venturi flow coefficients are determined on a total plant basis since the uncertainties in moisture carryover and measured flow coefficient could also represent some systematic biases in the test procedures. Finally, the loop power uncertainty is combined with the plant uncertainties due to moisture carryover and measured flow coefficient. Credit is taken in this step for the independence of the loop uncertainties. Reference flow testing was performed to quantify the feedwater venturi flow coefficients. The uncertainty of the flow coefficient was conservatively applied as 1% to the secondary side heat balance calculation.

Figures 1-3, 1-4 and 1-5 provide simplified schematics for the feedwater temperature, steam pressure, and feedwater flow differential pressure input to the plant computer. The component accuracies for the feedwater temperature, steam pressure and feedwater flow differential pressure input to the plant computer are shown in Tables 1-3, 1-4 and 1-5, respectively. Subsequent to our submittal, these have been revised from the input used to support Reference 1 as follows:

- The replacement of feedwater RTDs and a reduction in the corresponding calibration span from 600°F to 200°F.
- The inclusion of a revised STE (increase from 1.054% to 1.475%) for the steamline pressure transmitter to reflect a wider variation in containment ambient temperature.
- The reconfiguration of the input of feedwater flow differential pressure to the plant computer (i.e., the signal is not routed through the square-root function device).

In Reference 1, the uncertainty on core power was quantified as 1.390% at an uprated power 2942.2 MWt. This parameter uncertainty is treated as a normal, two-sided, 95%

probability distribution and its standard deviation was calculated by dividing this value by 1.96 to obtain 0.709%. The re-quantified uncertainty on core power using the revised uncertainty input is 1.250% at an uprated power 2942.2 MWt, and the corresponding standard deviation is 0.638%.

The standard deviation used for the implementation of the Statistical DNBR Evaluation Methodology was 0.771%, which included additional conservatism to allow for future changes in plant hardware or calibration procedures without invalidating the analysis. This standard deviation corresponds to a ±1.511% uncertainty, treated as a normal, two-sided, 95% probability distribution. This assumed uncertainty represents the minimum required accuracy for core power and bounds the quantified uncertainty.

RCS Flow

Dominion has quantified the uncertainty on the reactor coolant system (RCS) flow as measured by the control room board indication for the RCS loop elbow taps. RCS flow is determined by a precision flow calorimetric at the beginning of each cycle. The RCS flow is monitored by the cold leg elbow taps, which are normalized against the precision calorimetric. The inputs to the precision flow calorimetric are from power, hot leg temperature, and cold leg temperature. The power uncertainty is determined as previously discussed. Figures 1-6 and 1-7 provide simplified schematics for the hot and cold leg temperature input to the plant computer. Figure 1-8 provides a simplified schematic for the indication of the elbow tap output on the control board. The component accuracies for the hot and cold leg temperature input to the plant computer are shown in Table 1-7. The component accuracy for the elbow tap indicator is shown in Table 1-8. An additional uncertainty to the RCS flow is the effect of hot leg streaming. This is conservatively included both as random and systematic uncertainty.

The overall uncertainty is calculated as follows. First, uncertainties on RCS flow due to core power, RCS hot leg temperature, RCS cold leg temperature, elbow tap indication, and hot leg streaming are determined on a loop basis. These uncertainties are then combined to provide a loop RCS flow uncertainty. In the next step, the uncertainty on RCS flow due to hot leg streaming is determined on a plant basis to account for the fact that the uncertainty in hot leg streaming could also represent some systematic bias which could effect the RCS flow uncertainty. Finally, the loop RCS flow uncertainty is combined with the plant uncertainty due to hot leg streaming. Credit is taken in this step for the independence of the loop uncertainties.

In Reference 1, the uncertainty on RCS flow was quantified as 2.6048%. This parameter uncertainty is treated as a normal, two-sided, 95% probability distribution and its standard deviation was calculated by dividing this value by 1.96 to obtain 1.329%. Subsequent to our submittal, the RCS flow uncertainty was recalculated to credit the reduction in the core power uncertainty. The re-quantified uncertainty on RCS flow is 2.541%, and the corresponding standard deviation is 1.297%.

TABLE 1-2

RCS T_{AVG} Rod Control Signal

Variable	T_{HOT} % span		T_{COLD} % span
SCA	0.417	SCA	0.417
SMTE	0.170	SMTE	0.170
SD	0.250	SD	0.250
SPE	0.000	SPE	0.000
STE	0.000	STE	0.000
SPSE	0.000	SPSE	0.000
M1,M2,M3	0.500	M4	0.500
M1MTE,M2MTE, M3MTE	0.230	M4MTE	0.230
Output of RTD Amp.	0.967	Output of RTD Amp.	0.967
	T_{HOT} Summator		
M5	0.500		
M5MTE	0.120		
Output of Summator	0.834*		
	T_{AVG} Summator		
M6	0.500		
M6MTE	0.090		
PMA	1.700		
Output of Summator	1.956*		

* Transfer equations are required to calculate the output uncertainty for these devices.

TABLE 1-2 (continued)

RCS T_{AVG} Rod Control Signal

Variable	T_{AVG} % span		T_{REF} % span
	T_{AVG} Summing Amp.		**Turbine Impulse Pressure**
M7	0.500	SCA	0.500
M7MTE	0.060	SMTE	0.205
M8	0.200	SD	0.500
M8MTE	0.150	SPE	0.000
M9	0.200	STE	1.367
M9MTE	0.150	SPSE	0.000
M10	0.200	M14	0.100
M10MTE	0.150	M14MTE	0.153
M11	0.250	M15	0.500
M11MTE	0.200	M15MTE	0.100
M12	0.500	Output of Lead/Lag	1.743
M12MTE	0.100		
M13	0.500	**T_{REF} Summing Amp.**	
M13MTE	0.100	M16	0.250
Output of Lead/Lag	**2.330****	M16MTE	0.100
		Output of Summing Amplifier	0.789*
		M17	0.500
		M17MTE	0.100
		Output of Lead/Lag	**0.991*****

* Transfer equations are required to calculate the output uncertainty for this device.

** This is the Tavg uncertainty input into the Tavg/Tref deviation device.

*** This is the Tref uncertainty input into the Tavg/Tref deviation device.

TABLE 1-2 (continued)

RCS T_{AVG} Rod Control Signal

Variable	
Tavg uncertainty	2.330 %
Tref uncertainty	0.991 %
	Rack Effects
RD	1.000 %
RTE	0.500 %
RRA	0.000 %
CA*	1.697 %
CSA	3.25%
Span	100°F
CSA	3.25°F

* The Tavg controller deadband (CA) is ±1.5°F. This corresponds to an accuracy (1.96σ) of 1.697%, based on a uniform probability distribution.

TABLE 1-3

Feedwater Temperature Uncertainty

Variable	Feedwater Temperature Uncertainty (% span)
SE	0.000
EA	0.000
PMA	0.000
PEA	0.000
SCA	0.375
SMTE	0.000 (Note 1)
SD	0.375
SPE	0.000
STE	0.000
SPSE	0.500
M1	0.500
M1MTE	0.102
M2	0.000
M2MTE	0.000
M3	0.000
M3MTE	0.000
RD	1.000
RTE	0.500
RRA	0.000
CSA	1.464%
Span	200 °F
CSA	2.928 °F

(1) SMTE included in manufacturer's accuracy for the resistance vs. temperature curve.

TABLE 1-4

Steam Pressure Uncertainty

Variable	Steam Pressure Uncertainty % span
SE	0.000
EA	0.000
PMA	0.000
PEA	0.000
SCA	0.500
SMTE	0.207
SD	0.429
SPE	0.000
STE	1.475
SPSE	0.000
M1	0.100
M1MTE	0.153
M2	0.340
M2MTE	0.030
M3	0.000
M3MTE	0.000
RD	1.000
RTE	0.500
RRA	0.000
CSA	2.076%
Span	1400 psi
CSA	29.1 psi

TABLE 1-5

Feedwater Flow Uncertainty

Variable	Feedwater Flow Uncertainty
SE	0.000
EA	0.000
PMA	0.000
PEA	0.000
SCA	0.750
SMTE	0.187
SD	0.500
SPE	1.118
STE	1.152
SPSE	0.000
M1	0.100
M1MTE	0.153
M2	0.340
M2MTE	0.050
RD	1.000
RTE	0.500
RRA	0.000
CSA	2.274 % dp span
	1.315 % flow span
Span	5.00E+06 lbm/hr
CSA	6.57E+04 lbm/hr

TABLE 1-6

Core Power Uncertainty at 100% of 2942.2 MWt

Parameter	Span	Units	No. of Instrument Channels	CSA(%)	Process Uncertainty	
Feedwater Temperature	200	F	1	1.464	2.928	F
Main Steamline Pressure	1400	psi	3	2.076	16.78 *	psi
Feedwater Flow Differential Pressure	10	Volts	2	2.274	4.65E+05 *	lbm/hr
Moisture Carryover	0.1	%MCO	1	100	0.1	%MCO
Flow Coefficient					1.0	% power
Core Power	100	%		1.250		

* Includes credit for averaging of instrument channels

TABLE 1-7

RCS Hot and Cold Leg Temperature Uncertainties

Variable	T_{HOT} Uncertainty % span		T_{COLD} Uncertainty % span
	T_{HOT}		T_{COLD}
PMA	0.000	PMA	0.000
PEA	0.000	PEA	0.000
SCA	0.417	SCA	0.417
SMTE	0.170	SMTE	0.170
SD	0.250	SD	0.250
SPE	0.000	SPE	0.000
STE	0.000	STE	0.000
SPSE	0.000	SPSE	0.000
Error for sensor*	0.638 % 0.442 °F (120 °F span)	Error for sensor	0.638 % 0.766 °F (120 °F span)
RCA**	0.200 °F	RCA**	0.100 °F
RMTE	0.000 °F	RMTE	0.000 °F
CSA	0.485 °F	CSA	0.772 °F

* Includes credit for averaging of three sensors.

** The instrument loop calibration results are reviewed and verified to meet the specified uncertainty.

TABLE 1-8

RCS Elbow Tap Uncertainty

Variable	Elbow Tap Uncertainty % dp span
SE	0.000
EA	0.000
PMA	0.000
PEA	0.000
SCA	0.750
SMTE	0.240
SD	0.375
SPE	0.000
STE	0.906
SPSE	0.000
M1	0.100
M1MTE	0.153
M2	1.500
M2MTE	0.030
RD	1.000
RTE	0.500
RRA	1.000
Error for dp span terms*	1.416 % dp span
Error for flow span terms**	2.143 % flow span
CSA, Indicator***	2.322% flow span

* RSS((SCA+SMTE),SD,STE, (M1+M1MTE))

** RSS((M2+M2MTE),RD,RTE, RRA)

*** RSS(0.5*DP Span Terms*(120/95), Flow Span Terms)

TABLE 1-9

RCS Flow Uncertainty*

Variable	RCS Flow Uncertainty
Random Uncertainty Components	Uncertainty, %
Power	2.139
T_{HOT}	0.868
Streaming	1.332
T_{COLD}	1.250
Elbow Taps	2.322
Total Random Uncertainty on a loop-by-loop basis	3.749
Total Random Uncertainty on a plant-wide basis	2.165
Streaming(Bias),Plant	1.332
Total Plant Uncertainty	2.541
Standard Deviation	1.297

* The RCS flow uncertainty was recalculated to credit the reduction in the core power uncertainty.

FIGURE 1-1

Pressurizer Pressure Control Signal

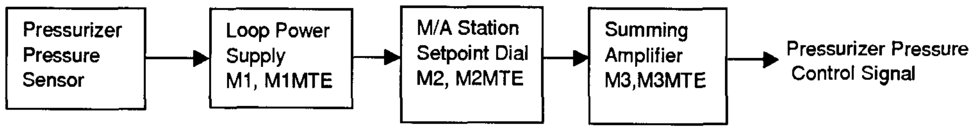
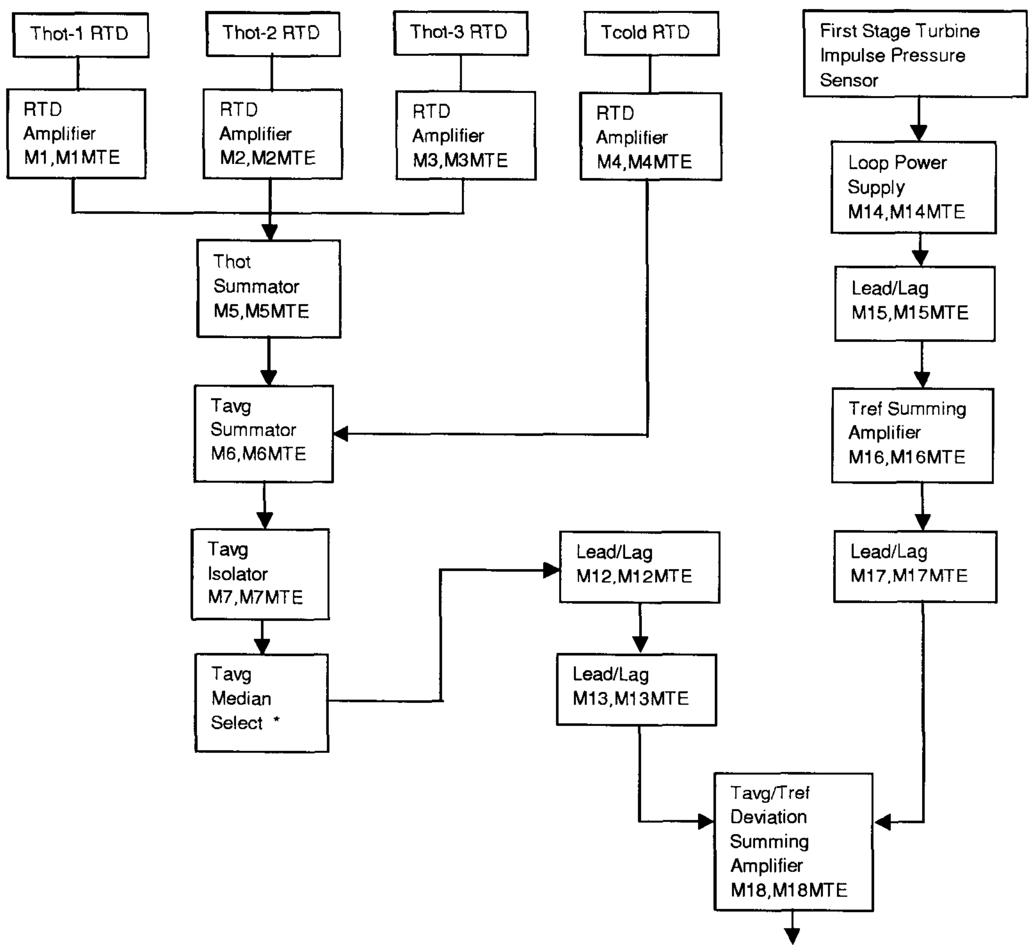


FIGURE 1-2

RCS TAVG Rod Control Signal



* The Tavg Median Select Module consists of four individual devices which are shown in Table 1-2 as M8,M8MTE to M11,M11MTE.

FIGURE 1-3

Feedwater Temperature Input to Plant Computer

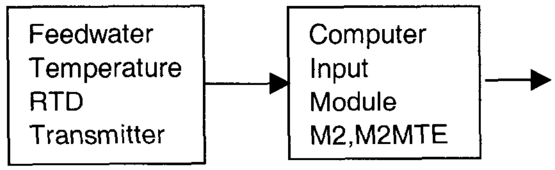


FIGURE 1-4

Steam Pressure Input to Plant Computer

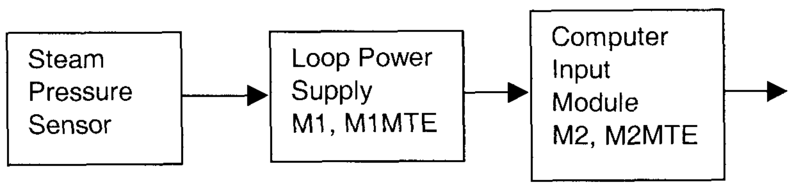


FIGURE 1-5

Feedwater Flow Differential Pressure Input to Plant Computer

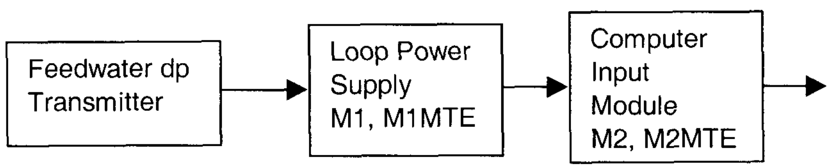


FIGURE 1-6

RCS Hot Leg Temperature Input to Plant Computer

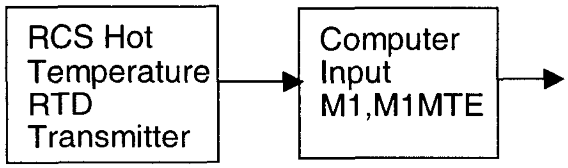


FIGURE 1-7

RCS Cold Leg Temperature Input to Plant Computer

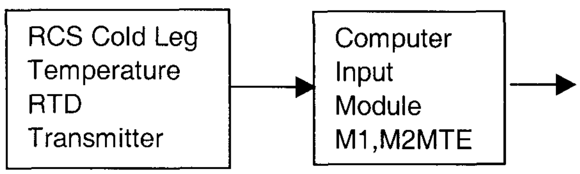
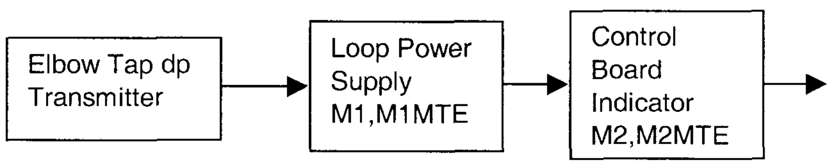


FIGURE 1-8

RCS Loop Flow Input to Plant Computer



NRC Question

2. *Section 3.1 indicates that a bounding rod census curve and the DNB sensitivity to rod power were used in the determination of the SDL that results in core wide DNB probability of less than 0.1% of the total fuel rods.*

   a. *Provide this bounding rod census curve, and describe the procedures to assure that the rod power distributions of North Anna 1 and 2 reload cores are bounded by this curve.*

Dominion Response

The reference fuel rod census curve used for the determination of the SDL is listed in Table 2-1. This reference fuel rod census is the same as used by AREVA to determine the LYNXT/BWU SDLs [Reference 4]. The fuel rod census is verified on a reload basis against the reference fuel rod census in accordance with the NRC-approved Reload Nuclear Design Methodology [Reference 3, Table 2, Item 21]. This is a key analysis parameter that is evaluated for each reload per Reference 3 to verify that the docketed safety analysis remains bounding.

Table 2-1: AREVA AMBW Reference Fuel Rod Census for a Maximum Peaking Factor FΔh = 1.587

MAXIMUM % OF FUEL RODS IN CORE WITH FΔh ≥	FΔh LIMIT
1	1.5618
2	1.5416
3	1.5275
4	1.5213
5	1.5122
6	1.5031
7	1.4920
8	1.4799
9	1.4698
10	1.4627
20	1.4466
30	1.3962
40	1.3349
CORE PEAK	**1.587**

b. Describe how the DNB sensitivity to rod power is obtained.

Dominion Response

The DNB sensitivity to rod power was estimated as $\partial(DNBR)/\partial(1/F\Delta h)$ using a linear regression analysis of the 2,000 random statepoints executed for each Nominal Statepoint. The specific values of $\partial(DNBR)/\partial(1/F\Delta h)$, denoted β, are listed in Tables 2-2 and 2-3 below for all evaluated Nominal Statepoints.

To ensure that the calculations were conservative, a one-sided tolerance limit of β was used:

$$\beta^* = \beta - t(\alpha,\nu) \cdot se(\beta)$$

in which

- β^* is the one-sided tolerance limit on β
- $t(\alpha,\nu)$ is the T-statistic with significance level α and ν degrees of freedom. For 2,000 observations at a 0.05 level of significance, t(0.05,2000) = 1.645.
- $se(\beta)$ is the standard error of β.

The variable 1/FΔh was the most statistically significant independent variable in the linear regression model, yielding R^2 values larger than 98%. The value of the statistic parameter F for 1/FΔh was the largest for all statepoints, which indicates that the variable 1/FΔh accounts for the largest amount of the variation in the DNBR.

Table 2-2: $\partial(DNBR)/\partial(1/F\Delta h)$ Estimation for BWU-Z/ZM

STATEPOINT	β	se(β)	β^*	R^2
A	4.74753	0.01565	4.72179	98.8%
B	6.02886	0.01942	5.99692	98.9%
C	4.93052	0.01536	4.90526	98.9%
D	5.75337	0.01752	5.72454	99.0%
E	4.88316	0.01474	4.85891	98.9%
F	5.26242	0.01572	5.23657	98.9%
G	4.78822	0.01437	4.76458	98.9%
H	4.94103	0.01452	4.91715	98.9%
I	5.49537	0.02106	5.46073	98.4%

Table 2-3: ∂(DNBR)/ ∂(1/FΔh) Estimation for BWU-N

STATEPOINT	β	se(β)	β*	R^2
A	4.34155	0.01594	4.31533	99.1%
B	3.81874	0.01379	3.79606	98.9%
C	4.27763	0.01474	4.25338	99.1%
D	3.96478	0.01353	3.94253	99.0%
E	4.16366	0.01423	4.14025	99.1%
F	3.96776	0.01350	3.94554	99.0%
G	4.10931	0.01442	4.08559	99.0%
H	3.95879	0.01334	3.93684	99.0%
I	4.06929	0.01548	4.04383	98.4%
A1	4.11919	0.01479	4.09487	99.0%
C1	4.02821	0.01415	4.00494	99.0%
E1	3.90567	0.01505	3.88091	98.8%
G1	3.87412	0.01460	3.85010	98.8%
A2	4.18412	0.01557	4.15852	99.1%
C2	4.07384	0.01470	4.04965	99.0%
H2	4.10404	0.01406	4.08092	99.0%

NRC Question

3. *Tables 3.1.6-1 and 3.1.6-2 list the nominal statepoints for the Advanced Mark-BW (AMBW) fuel with BWU-Z/ZM and BWU-N CHF correlations, respectively, for the Monte Carlo analysis.*

   Explain the reason for the selection of 9 statepoints with 0 axial offset and 16 statepoints with negative axial offsets for the BWU-Z/ZM and the BWU-N correlations, respectively.

Dominion Response

The methodology described in Reference 2 requires that several sets of base conditions, known as "Nominal Statepoints," be defined for each CHF correlation. Then, 2000 "Random Statepoints" are generated by the random number generators about each one of the Nominal Statepoints. The Nominal Statepoints must span the range of conditions over which the statistical methodology will be applied. To cover the range of full flow events, Nominal Statepoints are selected on the DNB-limiting portions of the Core Thermal Limits (CTLs), at the high and low temperature extremes, and at each of four representative pressures. In order to apply the methodology to low flow events, a low flow statepoint is also included.

The Nominal Statepoints for the BWU-Z/ZM correlation are listed in Table 3.1.6-1 in Reference 1. Two statepoints were selected at each of the four CTL pressures (2400, 2250, 2000 and 1860 psia). The values of 2400 psia and 1860 psia bound the high and low pressure reactor trip setpoints respectively, while 2250 and 2000 psia are included as representative intermediate points. Based on the definition of the North Anna CTLs, statepoints at 118% power (a safety analysis limit that bounds the overpower and high-flux reactor trip limits) and at a lower power were selected at each pressure. The lower power statepoint was located near the intercept of the DNBR limit line with the vessel exit boiling line. The inlet temperature used for each statepoint is calculated by determining the inlet temperature that would result in the desired MDNBR for each statepoint (A-H). In addition, a low flow statepoint (I) was selected.

The Nominal Statepoints for the BWU-Z/ZM CHF correlation used a 1.55 chopped cosine axial power shape (0.0 axial offset), consistent with the selection of the CTLs and with previous implementations of the USNRC-approved Statistical DNBR Evaluation Methodology [Reference 2]. Sensitivity studies were performed using positively and negatively skewed power shapes to demonstrate the appropriateness of the use of the 1.55 chopped cosine axial power shape, and it was concluded that the SDL calculated with the Statistical DNBR Evaluation Methodology is insensitive to the axial offset of the evaluated power shape.

The Nominal Statepoints (A-I) for the BWU-N CHF correlation correspond to the Nominal Statepoints for the BWU-Z/ZM correlation, but use a negatively skewed axial power shape with an axial offset of –48.0%. This was necessary in order to obtain the MDNBR below the first mixing vane (located at 46.7 in elevation), because that is the region of the fuel assembly where the BWU-N correlation is applicable. Seven additional Nominal Statepoints (A1, C1, E1, G1, A2, C2, H2) were also created using less skewed powershapes (-32.5% and -24.8%) that might result in MDNBR values below the first mixing vane, to evaluate the sensitivity of the results to the axial offset. The inlet temperature used for each statepoint is calculated by determining the inlet temperature that would result in the desired MDNBR for each statepoint.

All the Nominal Statepoints use a North Anna uprated power of 2942.2 MWt, and a nominal maximum statistical $F\Delta h_N$ of 1.587. The results of this analysis bound the current North Anna operating limits (2893 MWt and maximum statistical $F\Delta h_N$ of 1.538), and will be valid if Dominion chooses to uprate or increase the maximum statistical $F\Delta h_N$.

NRC Question

4. *To demonstrate that the selected nominal statepoints provide a bounding DNBR standard deviation for any set of conditions to which the statistical methodology may be applied, Section 3.1.8 indicates that a regression analysis was performed using the unrandomized DNBR standard deviations at each nominal statepoint as dependent variable and the nominal statepoint pressure, inlet temperatures, powers, and flow rates as independent variables. It concludes that all the regression analyses performed for each independent variable showed extremely low* R^2 *correlation factors, which indicates that the unrandomized DNBR standard deviations are not related to the independent variables evaluated. Figures 3.1.8-1 and 3.1.8-2 provide sample results for the BWU-Z/ZM and BWU-N correlations, respectively, that show the standard deviation of unrandomized DNBR at each*

statepoint as a function of inlet temperature, and linear regression functions and correlation coefficients, R^2.

a. *Clarify the term "unrandomized DNBR standard deviations at each nominal statepoint.*

Dominion Response

In accordance with the NRC-approved Dominion Statistical DNBR Evaluation Methodology [Reference 2], the analyses in Reference 1 generated 2,000 random statepoints about each of the Nominal Statepoints. Each one of the random statepoints was then executed with the VIPRE-D code, and a MDNBR value was obtained. The standard deviation for the distribution of the 2,000 MDNBRs obtained around each Nominal Statepoint is what Reference 1 refers to as the "unrandomized DNBR standard deviation at each nominal statepoint."

These standard deviations were termed "unrandomized" to distinguish them from the "randomized standard deviations" that are used at different points of the Statistical DNBR Evaluation Methodology. The "randomized" standard deviations are obtained by correcting the "unrandomized" standard deviations for the CHF correlation uncertainty.

b. *Provide and justify the limit value of R^2 used to determine whether the unrandomized DNBR standard deviations are related to an independent variable.*

Dominion Response

R^2 describes the strength of the association between the DNBR and the various independent variables, that is, the fraction of the variance of the DNBR that can be explained from the variance of the other variables. Even though a specific R^2 limit was not formalized, values of 50% or less indicate that the independent variable under study was statistically insignificant. Table 4-1 below lists the values of the R^2 correlation coefficients obtained for all the regression analyses performed to validate the selected Nominal Statepoints and shows that the R^2 values were at or below 50%.

The goal of these regression analyses was to show that the selected Nominal Statepoints provide a bounding standard deviation for any set of conditions to which the methodology may potentially be applied. Then, it was necessary to demonstrate that s_{TOTAL} as calculated in Reference 1 was maximized for any conceivable set of conditions at which the core may approach the SDL. This was performed as follows:

1) Plot the unrandomized DNBR standard deviations at each nominal statepoint as the dependent variable against the Nominal Statepoint pressures, inlet temperatures, powers and flow rates as the independent variables. Observe whether or not clear trends were noticeable assessing if increasing or decreasing the value of the independent variable would result in a higher unrandomized DNBR standard deviation. Such trends were not observed for any of the variables.

2) Linear curve fits were imposed to each set of variables, and the R^2 coefficients were logged. The largest R^2 was 40%.
3) Polynomial curve fits were imposed upon each set of variables, in an attempt to find whether or not some other relation could explain the data trends. The R^2 were logged again and the maximum was 50.6%.

An evaluation of all the data, linear fits, polynomial fits and R^2 coefficients indicates that there are no discernible trends in the database. Therefore, it was concluded that s_{TOTAL} had been maximized for any conceivable set of conditions at which the core may approach the SDL and that the selected Nominal Statepoints provide a bounding standard deviation for any set of conditions to which the methodology may potentially be applied.

c. *Provide the results of the regression analyses for all statistically treated parameters as independent variables.*

Dominion Response

Table 4-1 below lists the R^2 coefficients obtained for the verification of the Nominal Statepoints.

Table 4-1: R^2 Coefficients for the Verification of the Nominal Statepoints

	BWU-Z/ZM		BWU-N	
	R^2 Linear regression	R^2 Polynomial Regression [grade]	R^2 Linear regression	R^2 Polynomial Regression [grade]
PRESSURE	40.8%	41.0% [3]	11.1%	18.8% [2]
TEMPERATURE	3.4%	35.7% [4]	30.8%	31.1% [2]
FLOW RATE	0.1%	30.0% [4]	11.1%	50.6% [3]
POWER	21.6%	39.3% [3]	6.8%	47.2% [2]

NRC Question

5. *To verify that the existing reactor core safety limits and protection setpoints in the Technical Specifications remain acceptable as a result of implementation of the Statistical DNBR Evaluation Methodology to AREVA AMBW fuel at North Anna 1 and 2 with VIPRE-D/BWU, Section 3.2.6 describes the calculations performed for the selected statepoint conditions that include core thermal limits, axial offset envelopes, and several transient events, and concludes that the results of the calculation demonstrate that the minimum DNBR values are equal to or greater than the applicable safety analysis limit of 1.60.*

Provide the list of the selected statepoints and the calculation results for each statepoint.

Dominion Response

Table 5-1 lists the input conditions as well as the MDNBR results for all the statepoints used for the verification of the North Anna Statistical DNBR Design Limits and Safety Analysis Limits. These results were obtained with the VIPRE-D 14-Channel production model for North Anna. The results of the calculations demonstrate that the minimum DNBR values are equal to or greater than the applicable safety analysis limit of 1.60 for all the Reactor Core Safety Limits, the OTΔT, OPΔT and FΔI reactor trip setpoints, as well as all the evaluated Chapter 15 events (including the LOFA and LOCROT) with an $F_{\Delta H}^{N}$ of 1.587.

Table 5-1: Statepoints used for the verification of the North Anna Statistical DNBR Design Limits

Case #	Pressure [psia]	Power [%]	Temperature [°F]	Flow [%]	FΔH	AO [%]	MDNBR
1.1	2250.0	118	551.1	100	1.587	-48.0	1.723
2.1	2250.0	118	573.0	100	1.587	-32.5	1.752
3	2250.0	118	563.8	100	1.587	6.0	1.767
4	2250.0	118	561.0	100	1.587	9.8	1.804
5	2250.0	118	555.0	100	1.587	14.1	1.767
6	2250.0	118	547.3	100	1.587	20.5	1.831
7	2250.0	118	530.3	100	1.587	34.6	1.954
8	2250.0	118	521.3	100	1.587	43.0	1.995
9	2250.0	118	506.6	100	1.587	57.9	2.047
10	2400.0	80.0	626.2	100	1.682	0.0	1.743
11	2400.0	85.0	619.9	100	1.658	0.0	1.733
12	2400.0	90.0	613.4	100	1.634	0.0	1.739
13	2400.0	95.0	607.2	100	1.610	0.0	1.749
14	2400.0	100.0	601.2	100	1.587	0.0	1.763
15	2400.0	105.0	593.1	100	1.587	0.0	1.779
16	2400.0	110.0	584.9	100	1.587	0.0	1.807
17	2400.0	115.0	576.7	100	1.587	0.0	1.837
18	2400.0	118.0	571.9	100	1.587	0.0	1.851
19	2400.0	125.0	560.6	100	1.587	0.0	1.888
20	2400.0	130.0	552.7	100	1.587	0.0	1.911
21	2250.0	80.0	617.1	100	1.682	0.0	1.815
22	2250.0	85.0	611.1	100	1.658	0.0	1.787
23	2250.0	90.0	604.9	100	1.634	0.0	1.777
24	2250.0	95.0	598.8	100	1.610	0.0	1.774
25	2250.0	100.0	592.9	100	1.587	0.0	1.774
26	2250.0	105.0	584.3	100	1.587	0.0	1.787

Case #	Pressure [psia]	Power [%]	Temperature [°F]	Flow [%]	FΔH	AO [%]	MDNBR
27	2250.0	110.0	576.4	100	1.587	0.0	1.792
28	2250.0	115.0	568.6	100	1.587	0.0	1.798
29	2250.0	118.0	563.8	100	1.587	0.0	1.806
30	2250.0	125.0	552.5	100	1.587	0.0	1.827
31	2250.0	130.0	544.7	100	1.587	0.0	1.837
32	2000.0	80.0	604.5	100	1.682	0.0	1.915
33	2000.0	85.0	597.7	100	1.658	0.0	1.886
34	2000.0	90.0	591.2	100	1.634	0.0	1.863
35	2000.0	95.0	584.9	100	1.610	0.0	1.850
36	2000.0	100.0	578.9	100	1.587	0.0	1.837
37	2000.0	105.0	570.2	100	1.587	0.0	1.828
38	2000.0	110.0	561.8	100	1.587	0.0	1.823
39	2000.0	115.0	553.8	100	1.587	0.0	1.816
40	2000.0	118.0	549.1	100	1.587	0.0	1.811
41	2000.0	125.0	537.9	100	1.587	0.0	1.810
42	2000.0	130.0	529.8	100	1.587	0.0	1.812
43	1860.0	80.0	598.1	100	1.682	0.0	1.971
44	1860.0	85.0	590.9	100	1.658	0.0	1.938
45	1860.0	90.0	584.2	100	1.634	0.0	1.909
46	1860.0	95.0	577.7	100	1.610	0.0	1.889
47	1860.0	100.0	571.5	100	1.587	0.0	1.872
48	1860.0	105.0	562.6	100	1.587	0.0	1.857
49	1860.0	110.0	554.0	100	1.587	0.0	1.845
50	1860.0	115.0	545.7	100	1.587	0.0	1.835
51	1860.0	118.0	540.8	100	1.587	0.0	1.829
52	1860.0	125.0	529.4	100	1.587	0.0	1.822
53	1860.0	130.0	521.3	100	1.587	0.0	1.817
54	2400.0	130.0	552.7	100	1.587	0.0	1.911
55.1	2400.0	120.0	552.7	100	1.587	-48.0	1.748
56.1	2400.0	135.0	552.7	100	1.587	-32.5	1.776
57	2400.0	128.8	552.7	100	1.587	6.0	1.850
58	2400.0	118.9	552.7	100	1.587	20.5	1.915
59	2400.0	109.3	552.7	100	1.587	34.6	2.059
60	2250.0	130.0	544.8	100	1.587	0.0	1.834
61.1	2250.0	120.0	544.8	100	1.587	-48.0	1.750
62.1	2250.0	135.0	544.8	100	1.587	-32.5	1.785
63	2250.0	129.3	544.8	100	1.587	6.0	1.787
64	2250.0	119.2	544.8	100	1.587	20.5	1.842
65	2250.0	110.1	544.8	100	1.587	34.6	1.942
66	2000.0	130.0	529.8	100	1.587	0.0	1.812
67.1	2000.0	120.0	529.8	100	1.587	-48.0	1.744
68.1	2000.0	135.0	529.8	100	1.587	-32.5	1.768
69	2000.0	129.6	529.8	100	1.587	6.0	1.796

Case #	Pressure [psia]	Power [%]	Temperature [°F]	Flow [%]	FΔH	AO [%]	MDNBR
70	2000.0	121.0	529.8	100	1.587	20.5	1.775
71	2000.0	112.3	529.8	100	1.587	34.6	1.824
72	1860.0	130.0	521.3	100	1.587	0.0	1.817
73.1	1860.0	120.0	521.3	100	1.587	-48.0	1.739
74.1	1860.0	135.0	521.3	100	1.587	-32.5	1.750
75	1860.0	129.9	521.3	100	1.587	6.0	1.811
76	1860.0	121.3	521.3	100	1.587	20.5	1.782
77	1860.0	112.7	521.3	100	1.587	34.6	1.814
78	2400.0	118.0	571.9	100	1.587	0.0	1.851
79.1	2400.0	109.0	571.9	100	1.587	-48.0	1.764
80.1	2400.0	122.0	571.9	100	1.587	-32.5	1.811
81	2400.0	117.7	571.9	100	1.587	6.0	1.795
82	2400.0	109.0	571.9	100	1.587	20.5	1.832
83	2400.0	100.4	571.9	100	1.587	34.6	1.948
84	2250.0	118.0	563.8	100	1.587	0.0	1.806
85.1	2250.0	109.0	563.8	100	1.587	-48.0	1.763
86.1	2250.0	122.0	563.8	100	1.587	-32.5	1.818
87	2250.0	117.8	563.8	100	1.587	6.0	1.775
88	2250.0	110.0	563.8	100	1.587	20.5	1.764
89	2250.0	101.4	563.8	100	1.587	34.6	1.856
90	2000.0	118.0	549.1	100	1.587	0.0	1.811
91.1	2000.0	109.0	549.1	100	1.587	-48.0	1.748
92.1	2000.0	122.0	549.1	100	1.587	-32.5	1.782
93	2000.0	118.3	549.1	100	1.587	6.0	1.804
94	2000.0	110.6	549.1	100	1.587	20.5	1.773
95	2000.0	103.0	549.1	100	1.587	34.6	1.797
96.1	1860.0	118.0	540.8	100	1.587	0.0	1.829
97.1	1860.0	109.0	540.8	100	1.587	-48.0	1.739
98.1	1860.0	122.0	540.8	100	1.587	-32.5	1.769
99.1	1860.0	118.8	540.8	100	1.587	6.0	1.826
100.1	1860.0	111.0	540.8	100	1.587	20.5	1.790
101.1	1860.0	102.6	540.8	100	1.587	34.6	1.830
102	2400.0	100.0	601.2	100	1.587	0.0	1.763
103.1	2400.0	85.0	601.2	100	1.658	-48.0	1.831
104.1	2400.0	104.0	601.2	100	1.587	-32.5	1.765
105	2400.0	101.4	601.2	100	1.587	6.0	1.725
106.1	2400.0	91.8	601.2	100	1.626	20.5	1.727
107	2400.0	82.3	601.2	100	1.671	34.6	1.792
108	2250.0	100.0	592.9	100	1.587	0.0	1.774
109.1	2250.0	85.0	592.9	100	1.658	-48.0	1.831
110.1	2250.0	104.0	592.9	100	1.587	-32.5	1.737
111	2250.0	101.5	592.9	100	1.587	6.0	1.756
112	2250.0	92.4	592.9	100	1.623	20.5	1.736

Case #	Pressure [psia]	Power [%]	Temperature [°F]	Flow [%]	FΔH	AO [%]	MDNBR
113	2250.0	82.7	592.9	100	1.669	34.6	1.788
114	2000.0	100.0	578.9	100	1.587	0.0	1.837
115.1	2000.0	85.0	578.9	100	1.658	-48.0	1.798
116.1	2000.0	104.0	578.9	100	1.587	-32.5	1.737
117	2000.0	102.0	578.9	100	1.587	6.0	1.835
118	2000.0	94.3	578.9	100	1.614	20.5	1.774
119	2000.0	84.1	578.9	100	1.662	34.6	1.809
120	1860.0	100.0	571.5	100	1.587	0.0	1.872
121.1	1860.0	85.0	571.5	100	1.658	-48.0	1.765
122.1	1860.0	104.0	571.5	100	1.587	-32.5	1.720
123	1860.0	102.3	571.5	100	1.587	6.0	1.881
124	1860.0	95.0	571.5	100	1.610	20.5	1.814
125	1860.0	85.1	571.5	100	1.657	34.6	1.827
126.1	2400.0	80.0	626.2	100	1.682	0.0	1.743
127.1	2400.0	66.0	626.2	100	1.749	-48.0	1.769
128.1	2400.0	80.0	626.2	100	1.682	-32.5	1.740
129	2400.0	83.3	626.2	100	1.666	6.0	1.724
130	2400.0	76.8	626.2	100	1.697	20.5	1.698
131	2400.0	69.2	626.2	100	1.733	34.6	1.729
132.1	2250.0	80.0	617.7	100	1.682	0.0	1.801
133.1	2250.0	66.0	617.7	100	1.749	-48.0	1.783
134.1	2250.0	80.0	617.7	100	1.682	-32.5	1.756
135	2250.0	82.9	617.7	100	1.668	6.0	1.804
136	2250.0	77.1	617.7	100	1.695	20.5	1.749
137	2250.0	70.1	617.7	100	1.729	34.6	1.753
138.1	2000.0	80.0	604.5	100	1.682	0.0	1.915
139.1	2000.0	66.0	604.5	100	1.749	-48.0	1.750
140.1	2000.0	80.0	604.5	100	1.682	-32.5	1.732
141	2000.0	83.0	604.5	100	1.667	6.0	1.936
142	2000.0	77.7	604.5	100	1.693	20.5	1.854
143	2000.0	71.3	604.5	100	1.723	34.6	1.830
144.1	1860.0	80.0	598.1	100	1.682	0.0	1.971
145.1	1860.0	66.0	598.1	100	1.749	-48.0	1.717
146.1	1860.0	80.0	598.1	100	1.682	-32.5	1.703
147.1	1860.0	83.4	598.1	100	1.666	6.0	1.993
148	1860.0	78.2	598.1	100	1.690	20.5	1.911
149	1860.0	71.9	598.1	100	1.720	34.6	1.879
150	2250.0	100.00	554.2	100	1.490	0.0	3.073
151	2324.2	115.00	565.8	98	1.587	0.0	1.938
152	2250.0	100.00	554.2	100	1.945	0.0	1.849
153	2250.0	100.00	554.2	100	1.505	0.0	3.035
154.1	2300.0	98.00	555.0	68	1.538	0.0	1.824
155.1	2300.0	97.00	554.7	64	1.490	0.0	1.832

Case #	Pressure [psia]	Power [%]	Temperature [°F]	Flow [%]	FΔH	AO [%]	MDNBR
156	2250.0	118.00	551.1	100	1.587	-48.7	1.700
157	2250.0	118.00	551.1	100	1.587	-44.8	1.700
158	2250.0	118.00	551.1	100	1.587	-40.4	1.700
159	2250.0	118.00	551.1	100	1.587	-35.0	1.699
160	2250.0	118.00	551.1	100	1.587	-29.9	1.699
161	2250.0	118.00	551.1	100	1.587	-24.8	1.700
162	2250.0	118.00	551.1	100	1.587	-19.7	1.700
163	2250.0	118.00	551.1	100	1.587	-19.7	1.700
164	2250.0	118.00	551.1	100	1.587	-14.9	1.699
165	2250.0	118.00	551.1	100	1.587	-9.9	1.700
166	2250.0	118.00	551.1	100	1.587	-4.9	1.700
167	2250.0	118.00	551.1	100	1.587	-0.2	1.700
170	2350.0	98.0	555.00	67	1.587	0.0	1.672
171	2350.0	95.0	555.00	64	1.587	0.0	1.663
172	2350.0	98.0	555.00	67	1.538	0.0	1.831
173	2350.0	95.0	555.00	64	1.538	0.0	1.821
RWSC[a]	2320.0	35.66	551.7	100	1.968	-79.6	2.371
HF-MSLB [a]	901.5	20.8	446.9	99.7	5.688	22.3	4.086
LF-MSLB[a]	891.96	4.8	402.9	5.93	5.312	-96.0	5.881

[a] These are deterministic cases, and the applicable DNBR limits would be the DDLs listed in Table 3.2.4-1 in Reference 1.

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1. Letter from E. S. Grecheck (Dominion) to US NRC Document Control Desk, "Virginia Electric and Power Company North Anna Power Station Units 1 and 2 - Proposed Technical Specification Changes - Addition of Analytical Methodology to COLR," Serial No. 05-419, July 5, 2005.

2. Topical Report, VEP-NE-2-A, "Statistical DNBR Evaluation Methodology," June 1987.

3. Topical Report, VEP-FRD-42, Rev. 2.1-A, "Reload Nuclear Design Methodology," August 2003.

4. Letter from L. N. Hartz (Dominion) to US NRC Document Control Desk, "Virginia Electric and Power Company, North Anna Power Station Units 1 and 2, Proposed Technical Specifications Changes and Exemption Request, Use of Framatome ANP Advanced Mark-BW Fuel," Serial No. 02-167, dated March 28, 2002. (Proprietary version).

5. BAW-10170-A, "Statistical Core Design for Mixing Vane Cores," D. A. Farnsworth and G. A. Meyer, December, 1988.

6. Letter from S. Monarque (NRC) to D. A. Christian (Dominion), "North Anna Power Station, Unit Nos. 1 and 2 (North Anna 1 and 2) - Request for Additional Information on Proposed Technical Specification Changes on Addition of Analytical Methodology to the Core Operating Limits Report (TAC Nos. MC7526 and MC7527)," February 14, 2006.