Northeast
Utilities System

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Northeast Utilities Service Company
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September 30, 1994

Docket No. 50-213
B14955

Re: 10CFR2.790

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

Haddam Neck Plant
Response to Request for Additional Information, VIPRE/WRB-1
DNBR Thermal Limit for Westinghouse Fuel Types

The purpose of this letter is for Connecticut Yankee Atomic Power Company (CYAPCO) to respond to an NRC Staff request for information on the VIPRE/WRB-1 DNBR thermal limit for Westinghouse fuel types at the Haddam Neck Plant.

On November 29, 1993,[1] CYAPCO transmitted a topical report developed in support of Cycle 19 operation. The NRC Staff's letter of August 15, 1994,[2] transmitted requests for additional information on CYAPCO's November 29, 1993, submittal. During a discussion with the NRC Staff on the proposed responses, the need to respond to two additional issues were identified. The NRC Staff extended the requested response date to September 30, 1994, to provide CYAPCO sufficient time to respond to these additional items. CYAPCO has developed responses to these requests for information.

Enclosed with this letter are the following:

1. Response to Request for Additional Information, "VIPRE/WRB-1 DNBR Thermal Limit for Westinghouse Fuel Types" (Proprietary); and

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(1) J. F. Opeka letter to the U.S. Nuclear Regulatory Commission, "Transmittal of Topical Report, VIPRE/WRB-1 DNBR Thermal Limit for Westinghouse Fuel Types," dated November 29, 1993.

(2) A. B. Wang letter to J. F. Opeka, "Haddam Neck Plant - Request for Additional Information (TAC No. M88328)," dated August 15, 1994.

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2. Response to Request for Additional Information, "VIPRE/WRB-1 DNBR Thermal Limit for Westinghouse Fuel Types" (Non-Proprietary).

Also, Attachment 1 to this letter contains a Westinghouse application for withholding proprietary information from public disclosure (CAW-94-714), and accompanying affidavit, proprietary information notice and copyright notice.

As item 1 listed above contains information proprietary to Westinghouse Electric Corporation, it is supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of Section 2.790 of the Commission's regulations.

Accordingly, CYAPCO respectfully requests that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10CFR2.790 of the Commission's regulations.

Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse affidavit should reference CAW-94-714 and should be addressed to Mr. N. J. Liparulo, Manager of Nuclear Safety Regulatory and Licensing Activities, Westinghouse Electric Corporation, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Please contact Mr. E. P. Perkins, Jr. at (203) 665-3110 if you have any questions on this letter.

Very truly yours,

CONNECTICUT YANKEE ATOMIC POWER COMPANY

J. F. Opeka

J. F. Opeka
Executive Vice President

Attachment

cc: See Page 3

cc: T. T. Martin, Region I Administrator
A. B. Wang, NRC Project Manager, Haddam Neck Plant
W. J. Raymond, Senior Resident Inspector, Haddam Neck Plant

Attachment No. 1

Haddam Neck Plant

Westinghouse Proprietary Information Notice
Authorization Letter and Affidavit

September 1994

Docket No. 50-213
B14955

Enclosure 2

Haddam Neck Plant

Response to Request for Additional Information, VIPRE/WRB-1 DNBR Thermal Limit for Westinghouse Fuel Types

(NON-PROPRIETARY)

September 1994

QUESTION 1:

On June 27, 1994, Westinghouse informed the NRC Reactor Systems Branch staff that design corrective measures to resolve flow induced vibration problems for 17x17 Vantage 5H fuel with intermediate flow mixer grids has resulted in reduced DNBR margin.

Do you intend that your methodology be applicable for fuel with similar design characteristics? If so, please address how the appropriate penalty is to be determined and the magnitude of the penalty to be imposed.

RESPONSE:

The Cycle 19 fuel to be used at Connecticut Yankee is not designed with Intermediate Flow Mixer (IFM) grids. As such, the DNBR penalty discussed in question 1 does not need to be considered.

QUESTION 2:

(Page 4-5) A range of validity for the DNB correlation is given on this page. Please explain how your methodology assures that the correlation will not be used outside of the acceptable range.

RESPONSE:

An evaluation to ensure that the WRB-1 correlation is not used outside of its acceptable range will be performed as part of each transient analysis. For each transient, the range of parameters is verified by reviewing the VIPRE output. As in the response to question 5, the geometric parameters and the nominal RCS conditions are bounded by the test data. Thus, only those parameters that change are evaluated for each transient. In particular, pressure, quality and axial peaking are reviewed for each transient. This approach is identical to that used in verifying that the present DNBR correlation (W-3) is used within its acceptable range. The Cycle 19 Technical Report Supporting Cycle Operation (TRSCO) identifies the transients for which the WRB-1 correlation is applied. For Cycle 19, the WRB-1 DNB correlation will not be used for evaluating bottom peaked axial power distributions where the peak is below the first mixing vane grid (Uncontrolled Rod Withdrawal and Rod Ejection) and for evaluating transients where RCS pressure drops below 1440 psia (Steam Line Break). For these transients, the W-3, W-3L and/or Macbeth correlations are used, as is consistent with our currently approved methodology.

QUESTION 3:

(Page 22) Please provide a copy of Reference 1.

RESPONSE:

Reference 1 is a U. S. Department of Energy Report. Due to its length, we are sending only the applicable pages. These include the cover page, and pages 9, 10, and 51.

U.S. Department of Commerce
National Technical Information Service

SCR-607

FACTORS FOR ONE SIDED TOLERANCE LIMITS AND FOR VAIRABLES SAMPLING PLANS

U.S. DEPARTMENT OF ENERGY
WASHINGTON, DC

MAR 63

FACTORS FOR ONE-SIDED TOLERANCE LIMITS AND FOR VARIABLES SAMPLING PLANS

1. INTRODUCTION.

1.1 One-sided tolerance limits for a normal distribution.

For a normal random variable X with known mean μ and known standard deviation σ, it is possible to say that exactly a proportion P of the normal population is below $\mu + K_p\sigma$, where K_p is read from a table of the inverse normal probability distribution (e.g., see Reference [52], p. 12). For example, one can say that exactly 95% of the population is below $\mu + 1.64485\sigma$. The quantity $\mu + K_p\sigma$ is an upper tolerance limit.

In most cases, however, μ and σ are unknown and it is necessary to estimate both of them from a sample. Then a tolerance limit of the form $\bar{x} + ks$ may be used where $\bar{x}$ is an estimate of μ and s is an estimate of σ. Since $\bar{x}$ and s will be random variables, however, the tolerance limit statement can only be made with a given probability attached.

The problem then reduces to finding k such that the probability is γ that at least a proportion P of the population is below $\bar{x} + ks$. Tables of factors for one-sided tolerance limits for a normal distribution have been given in References [29], [37], [50], and [52] for the case where a sample $x_1, x_2, \ldots, x_n$ is taken and the sample mean,

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i,$$

and the sample standard deviation,

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2},$$

are computed.

A value of k is given in the tables of Section 2 such that "at least a proportion P of the normal population is less than $\bar{x} + ks$ with probability equal to γ." The value $\bar{x} + ks$ is called an upper tolerance limit. For a lower tolerance limit $\bar{x} - ks$ is used and the statement is "at least a proportion P of the population is greater than $\bar{x} - ks$ with confidence γ." If a two-sided limit is desired the reader is referred to References [12], [35], [52], and [76].

If the normal distribution has mean μ and standard deviation σ and either of these are known, there are entries in the tables of Sections 3 and 4 which will give the required tolerance limit. When the mean is known, k may be read from the tables of Section 4 with $n = \infty$, i.e., the tables of Sections 4.1.15, 4.2.15, and 4.3.15. Similarly, if the standard deviation is known, k may be read from the tables of Section 4 with $f = \infty$, i.e., as the last entry for each table. The tables of Sections 3.1, 3.2 and 3.3 may be useful if $n = 1$ or ∞ or if $f = 1$ or ∞.

It is convenient to define the term degrees of freedom for $\bar{x}$ as that value of n which occurs in the statement $\bar{x}$ has mean μ and standard deviation $\sigma/\sqrt{n}$. Similarly, the degrees of freedom for s is that value of f which occurs in the statement fs^2/σ^2 has a chi-square distribution with f degrees of freedom.

In addition to giving more extensive tables of k than [29], [37], and [50], this report extends the tables of k to the cases where the degrees of freedom for s are not necessarily one less than the degrees of freedom for $\bar{x}$. The degrees of freedom for s will be designated by f, and the degrees of freedom for $\bar{x}$ will be designated by n. Values for n = 1, 2, 3 and 4 only are given in [52] for this case where $f \neq n - 1$. The present report can also be considered an extension of the work in References [35] and [76] which cover the two-sided tolerance limit problem with $\bar{x}$ based on n degrees of freedom and s based on f degrees of freedom, where again f is not necessarily equal to n - 1. The extension given here, of course, is from the two-sided case to the one-sided case.

The values of k given in Sections 2, 3.1, 3.2, 3.3, and 4 correspond to percentage points (divided by the square root of n) of the noncentral t-distribution. Specifically,

$$\Pr\left\{\text{noncentral } t \leq k\sqrt{n} \,\middle|\, \delta = K_p\sqrt{n}\right\} = \gamma,$$

where the noncentral t has f degrees of freedom and K_p is such that $\Pr\left\{\text{a standardized normal variable} \leq K_p\right\} = P$.

1.2 Johnson and Welch type tables for computing k.

A discussion of the tables of Section 5 follows. Among other things these tables may be used whenever there is a combination of values of f, n, and P for which there is not an entry in the tables of Sections 2, 3 or 4 and for which interpolation in Sections 2, 3 or 4 would not be satisfactory. Note also that the values of γ which are available in Section 5 include $(1 - \gamma)$ for each γ listed since $\Pr\left\{\text{noncentral } t \leq t_e \,|\, \delta\right\} = 1 - \Pr\left\{\text{noncentral } t \leq -t_e \,|\, -\delta\right\}$ and both positive and negative values of t and δ appear in the tables.

Section 5 follows a procedure used by Johnson and Welch [32] and contains values of γ such that if

$$\eta = \frac{\delta}{\sqrt{2f}}\left(1 + \frac{\delta^2}{2f}\right)^{-\frac{1}{2}},$$

and

$$t_e = \frac{\delta + \lambda\left(1 + \frac{\delta^2}{2f} - \frac{\lambda^2}{2f}\right)^{\frac{1}{2}}}{\left(1 - \frac{\lambda^2}{2f}\right)}.$$

2.4 Values of k for $f = n - 1$ and $\gamma = .95$ (Continued)

$$\Pr\left\{T_f \leq k\sqrt{n} \mid K_p\sqrt{n}\right\} = \gamma$$

n	P: .75000	.90000	.95000	.97500	.99000	.99900	.99990	.99999
330	.778	1.410	1.792	2.124	2.512	3.323	3.992	4.573
335	.778	1.409	1.791	2.123	2.511	3.321	3.990	4.571
340	.777	1.408	1.790	2.122	2.509	3.319	3.988	4.568
345	.776	1.407	1.789	2.121	2.508	3.318	3.986	4.566
350	.775	1.406	1.787	2.119	2.506	3.316	3.983	4.564
355	.775	1.405	1.786	2.118	2.505	3.314	3.981	4.562
360	.774	1.404	1.785	2.117	2.504	3.312	3.980	4.559
365	.773	1.404	1.784	2.116	2.502	3.311	3.978	4.557
370	.772	1.403	1.783	2.115	2.501	3.309	3.976	4.555
375	.772	1.402	1.782	2.114	2.500	3.308	3.974	4.553
380	.771	1.401	1.781	2.113	2.499	3.306	3.972	4.551
385	.770	1.400	1.780	2.112	2.498	3.305	3.970	4.549
390	.770	1.399	1.780	2.111	2.496	3.303	3.969	4.547
395	.769	1.399	1.779	2.109	2.495	3.302	3.967	4.545
400	.769	1.398	1.778	2.109	2.494	3.300	3.965	4.543
425	.766	1.394	1.774	2.104	2.489	3.294	3.957	4.534
450	.763	1.391	1.770	2.100	2.484	3.288	3.950	4.526
475	.761	1.388	1.766	2.096	2.480	3.282	3.944	4.519
500	.758	1.385	1.763	2.092	2.475	3.277	3.938	4.512
525	.756	1.382	1.760	2.089	2.472	3.272	3.932	4.506
550	.754	1.380	1.757	2.086	2.468	3.268	3.927	4.500
575	.752	1.378	1.755	2.083	2.465	3.264	3.922	4.495
600	.751	1.376	1.752	2.080	2.462	3.260	3.918	4.489
625	.749	1.374	1.750	2.077	2.459	3.256	3.913	4.485
650	.748	1.372	1.748	2.075	2.456	3.253	3.910	4.480
675	.746	1.370	1.746	2.073	2.454	3.250	3.906	4.476
700	.745	1.368	1.744	2.071	2.451	3.247	3.902	4.472
725	.744	1.367	1.742	2.069	2.449	3.244	3.899	4.468
750	.743	1.365	1.741	2.067	2.447	3.241	3.896	4.465
775	.741	1.364	1.739	2.065	2.445	3.238	3.893	4.461
800	.740	1.363	1.737	2.063	2.443	3.236	3.890	4.458
825	.739	1.361	1.736	2.062	2.441	3.234	3.887	4.455
850	.738	1.360	1.734	2.060	2.439	3.232	3.885	4.452
875	.737	1.359	1.733	2.059	2.438	3.229	3.882	4.449
900	.736	1.358	1.732	2.057	2.436	3.227	3.880	4.446
925	.736	1.357	1.731	2.056	2.434	3.225	3.877	4.444
950	.735	1.356	1.729	2.054	2.433	3.224	3.875	4.441
975	.734	1.355	1.728	2.053	2.432	3.222	3.873	4.439
1000	.733	1.354	1.727	2.052	2.430	3.220	3.871	4.437
1500	.722	1.340	1.712	2.035	2.411	3.196	3.842	4.404
2000	.716	1.332	1.703	2.026	2.399	3.181	3.825	4.385
3000	.708	1.323	1.692	2.012	2.385	3.164	3.806	4.363
5000	.701	1.313	1.681	2.000	2.372	3.147	3.786	4.340
10000	.693	1.304	1.670	1.988	2.358	3.130	3.766	4.318
∞	.674	1.282	1.645	1.960	2.326	3.090	3.719	4.265

QUESTION 4:

The Tong "F-factor" is typically applied to account for nonuniform axial power profiles. This report does not mention whether the Tong F-factor is applied to the VIPRE simulations done by NUSCo. Is this axial factor, or any similar factor, applied to correct for axial nonuniformities? If so, please give the exact form of the equation used defining each of the terms.

RESPONSE:

The Tong F-factor is used in the NUSCo VIPRE analysis. The form of the Tong F-factor used in the VIPRE code for the WRB-1 DNB correlation is the same Tong F-factor used in the VIPRE code for the W-3 DNB correlation. The Tong F-factor used in the VIPRE code for the W-3 DNB correlation has previously been qualified. The form of the Tong F-factor used is taken from the VIPRE-01 computer code manual (EPRI Report - EPRI-NP-2511-CCM-A, V1, R3, page D-5). As part of the NUSCo VIPRE analysis to qualify use of the WRB-1 correlation, it has been verified that the Tong F-factor used in the WRB-1 DNB correlation produces the same results as the Tong F-factor used in the W-3 DNB correlation.

QUESTION 5:

Many of the parameters of the WRB-1 correlation involve geometrical features of the Westinghouse test data (rod diameters and pitch, equivalent and heated diameters, distance between grids, etc.). Please provide data for these parameters for the test sections and the Westinghouse fuel types considered. Demonstrate that the tested range of geometric parameters span the range of application of your methodology for licensing analysis.

RESPONSE:

The geometric ranges of the test assemblies used for the WRB-1 database and given on page 5 of the NUSCo Topical Report are compared to the NUSCo fuel parameters as follows:

Variable	WRB-1 Database	NUSCo Fuel
Pressure	$1440 \le P \le 2490$ psia	[ ] a,c
Local Mass Velocity	$0.9 \le G_{loc}/10^6 \le 3.7$ lb/ft^{2}hr	
Local Quality	$-0.2 \le X_{loc} \le 0.3$	
Heated Length	$L_H \le 14$ ft	
Grid Spacing	$13 \le g_{sp} \le 32$ in	

Variable	WRB-1 Database	NUSCo Fuel w/guide tube	NUSCo Fuel w/o guide tube
Equiv. Hydraulic Diam.	$0.37 \le D_E \le 0.60$ in	[	] a,c
Equiv. Heated Hydraulic Diameter	$0.46 \le D_H \le 0.58$ in		

* For the NUSCo fuel type, the equivalent heated hydraulic diameter is the only variable which falls outside the range of the tested WRB-1 database. However, justification for use of this fuel type is provided in Supplement 1 of WCAP-8762-P-A.

The following equations were used to calculate hydraulic diameters:

$$D_H = \text{equivalent heated hydraulic diameter} = \frac{(4)(\text{flow area})}{\text{heated perimeter}}$$

$$D_E = \text{equivalent hydraulic diameter} = \frac{(4)(\text{flow area})}{\text{wetted perimeter}}$$

The following values were used in calculating hydraulic diameters:

a) Channel without guide tube:

[ ]a,c

b) Channel with guide tube:

[ ]a,c

QUESTION 6:

Identify the two lines shown on figure 3 (page 17). On each of the figures 4, 5 and 6, please provide lines showing the best linear fit of the data shown as a function of variable plotted, as well as a line at the 95th percentile. This will help determine whether there are potential biases.

RESPONSE:

The two lines shown in Figure 3 of the Topical Report are as follows:

Upper Line - The upper line shows where measured heat flux equals predicted heat flux (i.e., slope = 1).

Lower Line - The lower line is the 95/95 line. 95% of the data will fall above this line with 95% confidence.

Figure 3 of the Topical Report is attached, with the two lines appropriately labeled.

As discussed in the conference call on 8/12, the NRC will review the database provided in the Topical Report to determine whether there are any potential biases in the data.

QUESTION 7:

The report does not address the nodalization utilized in the VIPRE simulation. Please provide information regarding the mesh spacing. The nodalization is important for determination of geometrical parameters for input to the WRB-1 correlation, in particular, the resolution which can be achieved for such parameters as heated length, L_H , and the distance from the most recent mixing vane grid, d_g?

RESPONSE:

The axial mesh spacing used in the NUSCo VIPRE analysis is identical to that used by Westinghouse in their THINC analysis of the same test configurations (WCAP-8762-P-A and WCAP-9401-P-A). Uniform axial mesh spacings were used for all test configurations, as follows:

a,c

Test Configuration	Axial Node Length (inches)
A-1	
A-2	
A-3	
A-4	
A-5	
A-6	
A-7	
A-8	
A-9	
A-10	
A-11	
A-12	
A-13	
A-14	
A-15	
A-16	
A-17	
A-18	
A-19	
A-20	
A-21	
A-22	

As part of the VIPRE/WRB-1 benchmarking analysis, the effect of axial mesh size on DNBR was evaluated. The results of this sensitivity study verified the acceptability of the axial mesh spacing used.

To account for the importance of geometric parameters used in the WRB-1 DNB correlation (such as distance from the most recent mixing vane grid, d_g), a second data set is input independent of the VIPRE axial nodalization. The following four values are entered in this data set:

Line 1 - The axial level, in inches, of the first mixing vane grid.

Line 2 - The grid spacing, in inches.

Line 3 - The grid performance factor, which varies based on rod diameter.

Line 4 - The number of mixing vanes used in the WRB-1 correlation.

Thus, the distance to each axial location is based upon the actual grid location and is not affected by the fact that the grid is not located at a node boundary.

For the purposes of qualifying the WRB-1 correlation, an effort was made to most closely match the nodalization used by Westinghouse in their THINC analysis. However, for the purpose of licensed core reload transient analysis, a finer axial node size is used in the region where DNB occurs, thus ensuring that the exit of the axial node falls as close as possible to the top of the grid. In developing the core reload VIPRE model, sensitivity studies were performed to determine the optimum node size in this region. The node size was chosen so as to ensure an accurate DNBR prediction. Additionally, the node boundaries are made to match with the top and bottom of the heated rod length.

QUESTION 8:

Tables A-1 through A-22 of the report list the hot channel and the hot rod in the bundle. Are they 'measured' or 'predicted'? Please provide the numbering scheme and radial layout of the VIPRE simulation. Do the 'predicted' channels and rods match those of the measured data?

RESPONSE:

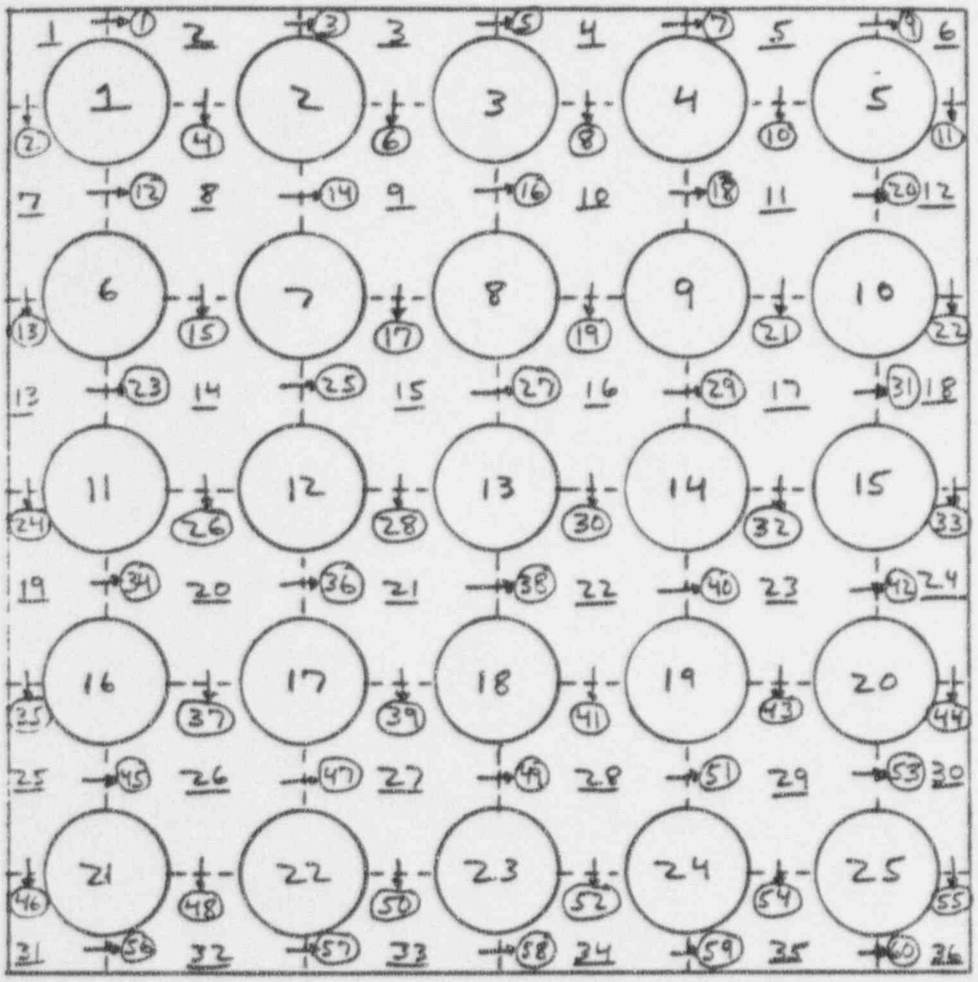
The hot channels and hot rods shown in Tables A-1 through A-22 of the NUSCo Topical Report are those which were predicted by the VIPRE code to experience minimum DNBR.

The rod and channel numbering schemes used in the NUSCo VIPRE analysis are attached.

The measured test data indicating which channel and rod experiences DNB is not readily available. Therefore, comparisons between 'measured' and 'predicted' rods cannot be made. Even if the measured data were easily accessible, only the rods which first reach DNB could be compared, since DNB was based upon thermocouple data from the rods and not the channels. In addition, because of the symmetry involved and the randomness in the rods which first experience DNB, this type of comparison is not likely to be very meaningful.

Regarding the axial DNB locations, both the predicted and measured elevations for DNB in WCAP-8762-P-A are with respect to the model used in the Westinghouse analysis rather than the actual thermocouple elevations. In the case of test configuration A-22, for example, the [ ] a,c length was divided into [ ] a,c steps, with DNBR calculations performed at the ends of the steps. A reported measured or predicted elevation of [ ] a,c inches, for example, corresponds to the beginning of length step 41 instead of the actual thermocouple elevation of [ ] a,c inches. This is also discussed in items 2 and 5 of the letter dated October 24, 1977 which is included in WCAP-8762-P-A.

In general, the VIPRE predicted axial locations obtained, if not matched perfectly, are within one axial node of the axial values used in the Westinghouse THINC analysis. This is acceptable, as it is within the accuracy of one axial node.

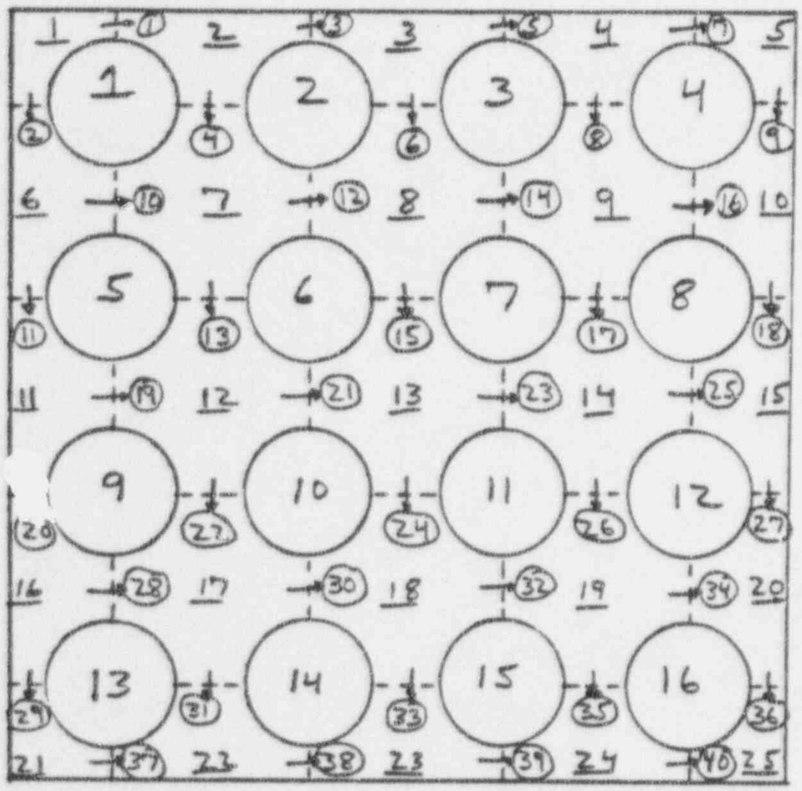


XX = Heated Rod Number

xx = Channel Number

→xx = Gap Connection Number

Schematic of VIPRE Model used for 5x5 Test Configurations



XX = Heated Rod Number

xx = Channel Number

→xx = Gap Connection Number

Schematic of VIPRE Model used for 4x4 Test Configurations

QUESTION 9:

Please include a copy of the applicable section(s) of "The Cycle 19 Technical Report Supporting Cycle Operation (TRSCO)", referenced in the preliminary response to the RAI (Question 2).

RESPONSE:

Section 7, "Accident and Transient Analysis" of the Haddam Neck Plant Cycle 19 Technical Report Supporting Cycle Operation is attached. The complete TRSCO has been transmitted to the NRC via CYAPCO's letter of September 23, 1994[1].

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(1) J. F. Opeka letter to the U.S. Nuclear Regulatory Commission, "Transmittal of Partial Technical Report Supporting Cycle 19 Operation," dated September 23, 1994.

7. Accident and Transient Analysis

The accident and transient analysis design basis was reviewed for potential impact due to changes in the Cycle 19 reload physics parameters contained in the Reload Safety Analysis Checklist (RSAC). Fuel design differences between B&W and Westinghouse manufactured assemblies required many modeling and assumption changes including bypass flow increase, slightly longer rod drop time, longer active fuel length of the Westinghouse assemblies, and the inclusion of the IFBA rods in some of the Westinghouse assemblies. Cycle 19 will have longer cycle length. The Rod Insertion Limit curve shown in Figure 8-1 was modified to ensure that the Nuclear Enthalpy Rise Hot Channel Factor limits shown in Section 8.0 remain valid at all power levels. The Cycle 19 Rod Insertion Limit curve is slightly more restrictive than the Cycle 18 Rod Insertion Limit curve, the difference between them being only at very low power.

Most of the Chapter 15 (Reference 1) non-LOCA transients were reevaluated and all results were shown to be acceptable. The review of the LOCA and non-LOCA transient design bases for Cycle 19 is discussed below:

Small Break LOCA

For Cycle 19, the small break LOCA design basis was updated due to the changes discussed above. The ECCS performance has been analyzed by NUSCO under the criteria set forth in 10CFR50.46 using the evaluation model based on the NULAP5 code methodology previously submitted as Reference 16.

The input to the evaluation model has been revised to incorporate the new Westinghouse fuel assembly which includes a longer active fuel length. The new assembly has a higher hydraulic resistance and a higher core bypass flow than the B&W assembly. The stored energy and rod internal pressure have been changed as well.

The update to the core physics data included the revised scram reactivity insertion curve. The radial power factor in the channel representing the hot assemblies was increased to 1.56 which bounds the maximum expected measured value with a 4% uncertainty included.

Following the revisions to the input data, a complete re-analysis of the previous break spectrum was performed. The analysis confirmed the worst small break as the 0.075 FT^2 break in a cold leg as for the previous cycle. The calculated peak cladding surface temperature was 1215°F in the hot rod. The hot rod and the core-wide oxidation was calculated to be negligible.

Four thrice burnt Stainless Steel-clad assemblies will remain in the core for Cycle 19. These assemblies will have power factors at or below core average. They will not be limiting because of the low power and reduced stored energy associated with the burnup of the fuel. Therefore, these assemblies are bounded by the Zircaloy-clad fuel.

The results of the new break spectrum analysis and the limiting break will be used to update the Haddam Neck Plant UFSAR.

Large Break LOCA

LATER

Non-LOCA Transients

The design basis non-LOCA transients were reevaluated for potential impact due to changes in the Cycle 19 reload physics parameters and the design changes associated with the use of Westinghouse fuel. The WRB-1 DNB correlation (Reference 12) and the Westinghouse thermal design methodology (Reference 15) are being applied for the Cycle 19 reload. Minor changes due to the new fuel design, including an increase in the core bypass flow fraction from 4.5 percent to 5.7 percent and a change in the scram reactivity insertion curve were also included in the evaluation.

The following Chapter 15 (Reference 1) non-LOCA transients were re-analyzed:

- Uncontrolled Rod Withdrawal
- Boron Dilution
- Excessive Load Increase
- Dropped Rod
- Rod Ejection
- Loss of Flow
- Steam Line Break
- Loss of Load
- Loss of Feedwater
- RCP Locked Rotor/Shaft Seizure

The reanalyses were performed using the same methods as used previously (References 9 and 22) except for the DNB correlation and thermal design methodology as stated above.

Steam Generator Tube Rupture and Excess Feedwater transients were not reanalyzed. The Steam Generator Tube Rupture analysis is not DNB dependent and hence not affected by the changes. The results of Excess Feedwater were bounded by the results of Excessive Load Increase.

The reanalysis results are discussed below.

Boron Dilution

The Boron Dilution transient was reanalyzed due to the changes in the associated Cycle 19 reload physics parameters. The results of the Boron Dilution analysis required a change to the Modes 4 and 5 Shutdown Margin Technical Specification (Reference 25). The Cycle 19 Critical Boron Concentration and Inverse Boron Worth have changed from the values used in the Reference 9 analysis. In addition, the boron dilution alarm assumed for the analysis was more conservatively modeled to take into account the potential for a non-linear response of the nuclear instrumentation seen in previous start-up testing. The shutdown margin requirements for Modes 4 and 5 are increased from 3400 pcm to 4200 pcm and 4500 pcm, respectively, for Cycle 19 to compensate for these changes. These higher shutdown margin requirements are shown to preserve the required operator action time of 15 minutes. The results indicate that the operator action acceptance criterion of 15 minutes for Modes 1 through 3 and 30 minutes for Mode 6 will continue to be satisfied with the current shutdown margin requirement.

Scram Reactivity Insertion

The total reactivity insertion time is bounded by the Cycle 18 value for the Westinghouse fuel design. However, the rate of insertion over the insertion time is different. This could have an impact on the fast reactivity transients like Rod Ejection. The change in scram reactivity insertion along with bounding values for ejected rod worth were modeled with RETRAN and compared to the current design. The RETRAN results show that the changes for Cycle 19 have no significant impact on the transient power response. Similarly, the new scram insertion curve together with Cycle 19 bounding values for maximum differential rod worth were modeled with RETRAN for the Uncontrolled Rod Withdrawal from Subcritical. The RETRAN results show no significant impact due to the Cycle 19 changes. Since the total insertion time is unchanged, and the RETRAN results for the fast reactivity transients showed no significant impact, RETRAN analysis for the other transients is bounded, and was not performed.

DNBR Analysis

For the DNBR analysis, both B&W and Westinghouse fuel were evaluated because the Cycle 19 core will consist of both fuel types. For the VIPRE model, the assumption of inlet flow maldistribution was modeled as a 5 percent reduction in coolant flow to the hot assembly instead of modeling a 3 percent flow penalty directly applied to the radial peaking factor as done previously. This is consistent with the Westinghouse standard methodology. The design DNBR limits used for the Cycle 19 reload have been determined in Reference 15 using the WRB-1 correlation for the Westinghouse fuel and the previous W-3L correlation for the B&W fuel. The design DNBR limits determined include a 3 percent transition core DNBR penalty for the Westinghouse fuel. Using the DNBR limits and the thermal design methodology described in Reference 15, the following transients were reevaluated.

- Uncontrolled Rod Withdrawal at Power
- Excessive Load Increase
- Dropped Rod
- Loss of Flow
- Loss of Load
- Loss of Feedwater
- RCP Locked Rotor/Shaft Seizure

For all the transients evaluated, the effects of the changes in RSAC parameters, core bypass flow fraction, and core flow maldistribution assumption were insignificant because the minimum DNBR and the maximum fuel centerline temperature, for both the B&W and Westinghouse core models, remain well within the acceptable design limits. The minimum DNBR results using the mini-RTDP methodology (Reference 15) for the Westinghouse core showed that there is at least 50 percent margin to the design DNBR limit. An ample margin (approximately 20 percent) to the design DNBR limit was also seen for the B&W core model.

Because the WRB-1 DNB correlation is not applicable for low pressure transients such as Steam Line Break, W-3 and Macbeth correlations are used for the Steam Line Break analysis. Also since the thermal design methodology described in Reference 15 is not applicable for the transients which the RSAC parameters are outside the range of the sensitivity performed for the statistical combination of uncertainties associated with power peaking, the following transients were evaluated using the W-3 DNB correlation and the current thermal design methodology used for the previous cycles.

- Uncontrolled Rod Withdrawal from Subcritical
- Rod Ejection
- Steam Line Break

For these transients, the effects of the changes in RSAC parameters, core bypass flow fraction, and inlet flow maldistribution assumption were insignificant because the results of the reanalysis show that the minimum DNBR and the maximum fuel centerline temperature remain within the acceptable fuel design limits for both B&W and Westinghouse core models.

Based on the analyses performed and review of the proposed revisions to Technical Specifications and Core Operating Limits, it is concluded that the Haddam Neck plant can be operated safely at the licensed thermal power level of 1825 MWt for Cycle 19.

Question 10:

More detail should be provided in response to RAI Questions 7 and 8, which address the VIPRE methodology used by NUSCO. These questions relate to nodalization and the accuracy of the prediction of the location of DNB. The accuracy of the WRB-1 DNBR correlation is highly dependent on the ability of the NUSCO VIPRE model to predict the axial location of DNB. Specifically:

a. Clarify the method used to obtain d_g and L_H and other thermohydraulic parameters input to the WRB1 correlation. How does the axial level specified in TABLES A1-A22 correspond with d_g and L_H? Are all the data items (d_g and L_H, and other thermohydraulic parameters) taken from the same axial location in the node? Is this axial level specified, the top of the DNB node, the bottom of the DNB node, or some other axial level?

Response:

The thermal-hydraulic parameters used in the WRB-1 DNBR correlation are determined as follows:

d_g = (distance from the previous upstream mixing vane grid). For all axial nodes except those within which a mixing vane grid exists, this is the distance from the upper boundary of the node containing the previous upstream mixing vane grid to the upper boundary of the node being considered. For calculation of the nodes which contain a mixing vane grid, dg is the grid spacing input on line 2 of the WRB-1 specific data input set (see response to question 7 of the RAI).

L_H = (Heated length). For all axial nodes, this parameter is the measurement from the upper boundary of the first non-zero heat flux elevation to the upper boundary of the node being considered.

The other thermal-hydraulic parameters used in the WRB-1 DNBR correlation include local Pressure, local Mass Velocity, Local Quality, Equivalent Hydraulic Diameter and Equivalent Heated Hydraulic Diameter. The values used for local Pressure, Mass Velocity and Quality are values at the upper boundary of the node being considered. The hydraulic diameter values are directly input to the VIPRE Code, as discussed in the response to question 5 of the RAI.

The following example shows how the axial level specified in Tables A1-A22 corresponds with d_g and L_H. For this example, test configuration A-9 will be used. As seen in Table A-9, for Case 1, the VIPRE predicted MDNBR occurs at an axial level of 151.2 inches. This axial level is the upper boundary of the node which contains the upper-most mixing vane grid for test configuration A-9. The values of d_g and L_H used in the WRB-1 DNBR correlation at this axial location are as follows:

d_g = 26.0 inches (note: this is also the grid spacing for this test configuration)

L_H = 147.84 inches

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Question 10:

b. In the preliminary response to the RAI (Question 8), NUSCO stated that their VIPRE model generally predicts the axial node of DNB within one axial node. It further states that this level of accuracy is acceptable. Please provide information which supports this conclusion, such as the results of any study or uncertainty analyses which were performed to determine the adequacy of the axial nodalization used by NUSCO.

Response:

The method used to confirm the adequacy of the axial noding size used in the VIPRE/WRB-1 benchmarking analysis is as follows:

To perform this sensitivity study, the VIPRE base deck developed for Test Section A-9 of the WRB-1 Database was used. This basedeck was developed using [ ]a,c (identical to the node size used by Westinghouse in WCAP 8762). DNBR values were obtained using VIPRE for this constant mesh deck.

The same deck was then adjusted for a variable axial mesh. The variable mesh was made in the upper 40% of the test section geometry. Two sets of runs were made. In the first set of runs, the upper 40% of the axial nodes was made greater than the constant axial mesh length used above (4.80 inches was used in the upper 40%). In the second set of runs, the upper 40% of the axial nodes was made less than the constant axial mesh used above (2.40 inches was used in the upper 40%). In both cases, the constant mesh in the lower 60% of the axial length was adjusted so that the constant mesh lengths plus variable length mesh equals total length.

Cases 1,2,3 and 15 of Test Configuration A-9 (Table A-9 of the NUSCO Topical Report) were evaluated in this way.

The DNBR values for each of the above sets of runs were compared in terms of axial DNBR distribution and axial location of the minimum DNBR. The maximum difference for all the cases was 0.22%.

The results obtained are as follows:

<u>Sensitivity Runs for Variable Axial Mesh (A-9 Configuration)</u>

	Base Case (Uniform Node)	Case A (Variable Node)	Case B (Variable Node)
Noding Scheme	[ ] a,c	[ ] a,c	[ ] a,c
Case 1 MDNBR Axial LOC	 0.927 151.2	 0.929 153.6	 0.926 151.2
Case 2 MDNBR Axial LOC	 0.898 151.2	 0.898 153.6	 0.897 151.2
Case 3 MDNBR Axial LOC	 1.037 151.2	 1.037 153.6	 1.036 151.2
Case 15 MDNBR Axial LOC	 0.962 151.2	 0.960 153.6	 0.962 151.2

Question 10:

c. Please provide the differences in nodalization between the models used by NUSCO for the benchmarking studies and proposed for use in reload licensing analysis (Question 7).

Response:

Benchmarking Cases

The nodalization for the models used to benchmark the WRB-1 correlation, as discussed in the response to question No. 7 of the RAI, employed uniform axial node sizes equivalent to those used by Westinghouse in their THINC analysis for WRB-1.

Licensed Reload Analysis

The VIPRE basedeck used for reload licensing analysis uses a variable mesh scheme. In this model, this scheme is essentially the same as in the current approved methodology; four axial zones are used, with each zone consisting of a uniform mesh size, as follows:

Zone No:	No. of Nodes	Node Length	Height of Top of Zone
1	1	1.83	1.83
2	16	5.09	83.26
3	16	2.44	122.30
4	1	6.13	128.43

Sensitivity studies with respect to axial node size and grid location were performed to ensure the acceptability of this noding. In this study, the axial node size was varied from approximately 1.5 to 2.5 inches in the expected MDNBR region. From this sensitivity study it was concluded that for node size less than approximately 2.5 inches, there is no significant effect on DNBR. A 0.05% difference in MDNBR was observed between node sizing of 1.5 and 2.5 inches, with no effect on axial MDNBR location.

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CLARIFICATION (System Pressure):

During the NUSCo/NRC conference call on Friday, August 12, the NRC raised a question regarding the system pressures used in the NUSCo VIPRE analysis and shown in tables A-1 through A-22 of the Topical Report. The NRC stated that NUSCo added 14.7 psi to the values used by Westinghouse in WCAP-8762-P-A. To clarify, the pressure values used by NUSCo and listed in tables A-1 through A-22 of the Topical Report are identical to the values used by Westinghouse in WCAP-8762-P-A (approved version, July, 1984) and WCAP-9401-P-A (approved version, August, 1981). NUSCo did not add 14.7 psi to the WCAP pressure values.