Progress Energy

Crystal River Nuclear Plant
Docket No. 50-302
Operating License No. DPR-72

Ref: 10 CFR 9.17
10 CFR 2.790

June 9, 2003
3F0603-10

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

Subject: Crystal River Unit 3 – Non-Proprietary version of the Supplement to Proposed License Amendment Request #277, Revision 0, "BHTP Departure From Nucleate Boiling Correlation"

References: 1) PEF to NRC letter, dated December 19, 2002, Crystal River Unit 3 – License Amendment Request #277, Revision 0, "BHTP Departure From Nucleate Boiling Correlation"

2) PEF to NRC letter, dated May 9, 2003, Crystal River Unit 3 – Supplement to Proposed License Amendment Request #277, Revision 0, "BHTP Departure From Nucleate Boiling Correlation"

Dear Sir:

In Reference 2, Progress Energy Florida, Inc. (PEF) submitted supplemental information for License Amendment Request (LAR) #277. PEF had requested that the supplemental information be withheld from public disclosure in accordance with 10 CFR 9.17(a)(4), 2.790(a)(4) and 2.790(d)(1). This letter transmits a non-proprietary version of that information for inclusion in the Public Document Room. The non-proprietary information is provided in the attachment to this letter.

No new regulatory commitments are made in this letter.

If you have any questions regarding this submittal, please contact Mr. Sid Powell, Supervisor, Licensing and Regulatory Programs at (352) 563-4883.

Sincerely,

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

A001

Progress Energy Florida, Inc.
Crystal River Nuclear Plant
15760 W. Powerline Street
Crystal River, FL 34428

DEY/pei

Attachment: Non-Proprietary Supplemental Information

xc: Regional Administrator, Region II
Senior Resident Inspector
NRR Project Manager

STATE OF FLORIDA

COUNTY OF CITRUS

Dale E. Young states that he is the Vice President, Crystal River Nuclear Plant for Progress Energy Florida, Inc.; that he is authorized on the part of said company to sign and file with the Nuclear Regulatory Commission the information attached hereto; and that all such statements made and matters set forth therein are true and correct to the best of his knowledge, information, and belief.

Dale E. Young

Dale E. Young
Vice President
Crystal River Nuclear Plant

The foregoing document was acknowledged before me this 9th day of June, 2003, by Dale E. Young.

Janet Schroeder

Signature of Notary Public
State of Florida

JANET SCHROEDER
MY COMMISSION # DD 128063
EXPIRES: June 20, 2006
Bonded Thru Notary Public Underwriters

(Print, type, or stamp Commissioned Name of Notary Public)

Personally Known ✓ -OR- Produced Identification ______

PROGRESS ENERGY FLORIDA, INC.

CRYSTAL RIVER UNIT 3

DOCKET NUMBER 50 - 302 / LICENSE NUMBER DPR - 72

ATTACHMENT

LICENSE AMENDMENT REQUEST #277, REVISION 0
BHTP Departure From Nucleate Boiling Correlation
Non-Proprietary Supplemental Information

REQUEST 1: Explain why the current Improved Technical Specification (ITS) Figure 2.1.1-1 safety limit line remains applicable and bounding for the Mark-B-HTP fuel design evaluated with the BHTP DNB correlation.

EXPLANATION

The DNB-based safety limit line presented in Improved Technical Specification (ITS) Figure 2.1.1-1 for CR-3 Cycle 14 application reflects no change in the current Cycle 13 DNB-based safety limit line. The acceptability of applying the same safety limit line for Cycles 13 and 14 is a result of the significant conservatism contained within the Tech Spec safety limit line. The safety limit line shown in Figure 2.1.1-1 was generated and applied in the 1970's for CR-3. It was based directly on the thermal-hydraulic codes, methodologies, CHF correlations, and fuel designs that Babcock & Wilcox used at that time for CR-3. The variable low pressure trip (VLPT) function is used to provide the necessary protection that the plant does not operate at the RCS pressures and temperatures that would exceed or violate the Tech Spec safety limit line (see Figure 1).

As newer NRC-approved thermal-hydraulic codes, methodologies, and correlations were introduced into the DNB analyses for CR-3 the earlier safety limit line was found to be bounding and conservative and was, therefore, retained since the utility was satisfied with the operating flexibility already provided by the VLPT. Had the DNB performance for such changes been found to be unbounded by the Tech Spec safety limit line, a new and more restrictive Tech Spec safety limit line would have been computed and shown in Figure 2.1.1-1 that could have led to a possible further tightening in the VLPT setpoints.

Figure 1

Pressure-Temperature Trip Limits and the Tech Spec Safety Limit

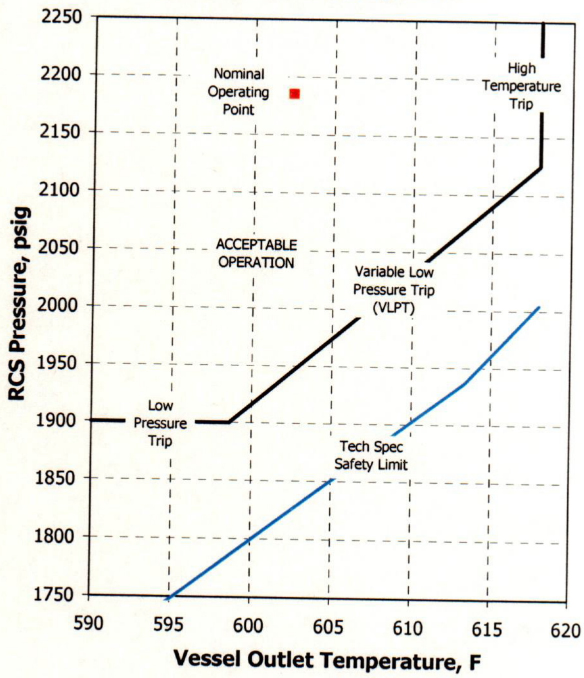
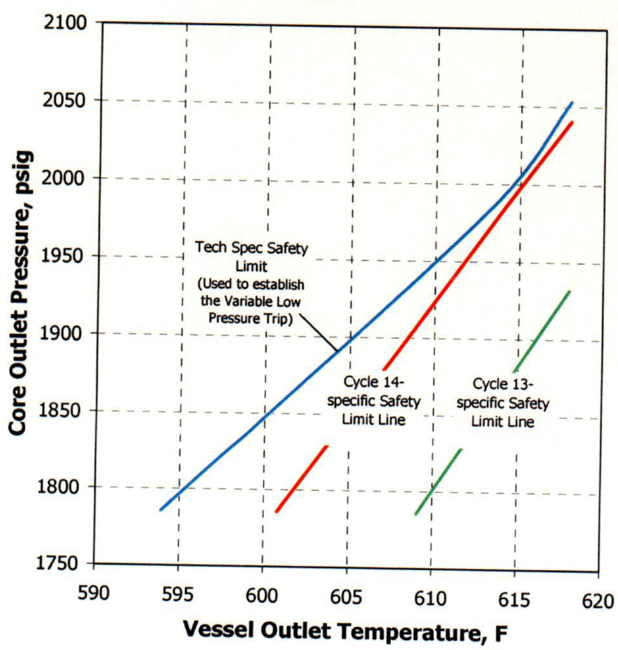


Figure 2

Cycle 13-specific and Cycle 14-specific DNB-Based Safety Limit Lines Compared to the Conservative Tech Spec Safety Limit



The attached Figure 2 shows the difference, in pressure-temperature space, between the Cycle 13 –specific safety limit line and the conservative safety limit line from Figure 2.1.1-1. The Cycle 13-specific safety limit line represents the combinations of RCS pressure and vessel outlet temperature that yield DNB predictions equal to the DNB design limit. The DNB predictions for Cycle

13 utilized the LYNXT thermal-hydraulic code (Reference 1), the Statistical Core Design methodology (Reference 2), the BWC CHF correlation (Reference 3), and a LYNXT model of a full core of Mark-B10 fuel. Framatome ANP's 50.59 topical report (Reference 4) provides the common source and linkage for these tools and methods when applied to the CR-3 Cycle 13 core. The Cycle 13-specific safety limit line reflects pressure-temperature conditions that yield a Thermal Design Limit (TDL) of [ ] with the BWC CHF correlation for the limiting steady-state reactor coolant pump condition. Since CR-3 is permitted to operate with 4 or 3 reactor coolant pumps, safety limit lines are determined for both 4 pump and 3 pump steady-state operation. The more limiting of the two cycle-specific safety limit lines (typically 4 pump operation) are shown in Figure 2 for Cycle 13 and is used to determine whether the Tech Spec safety limit line is bounding.

The value of the TDL incorporates the 1.18 BWC design limit, the impact of statistically treated uncertainties, and additional DNB margin for cycle-specific needs. The combined effect is an elevated design limit (TDL) of [ ] using the BWC correlation shown in Figure 3.

Figure 3

Thermal Design Limit (TDL) Bases for CR-3 Cycles 13 and 14

[ ]

The planned introduction of a new fuel design, the Mark-B-HTP, into Cycle 14 required a reanalysis of the DNB performance for the core. Two particular characteristics of the Mark-B-HTP fuel design forced the reanalysis: 1) the Mark-B-HTP fuel assembly has a slightly higher pressure drop than the resident Mark-B10 fuel design, and 2) the Mark-B-HTP fuel assembly requires the use of a new CHF correlation, the BHTP correlation (Reference 6).

The determination of the DNB transition core penalty is discussed in the explanation for REQUEST 2. The TDL for Cycle 14 was established to provide DNB margin above the SDL to offset the transition core penalty as well as any other cycle-specific needs that might be encountered. This flexibility for accommodating cycle-specific needs is discussed in Section 5 of Reference 2.

The DNB predictions for Cycle 14 again utilized the LYNXT thermal-hydraulic code and Statistical Core Design methodology. However for Cycle 14, the BHTP CHF correlation (Reference 6) and the LYNXT model of a full core of Mark-B-HTP fuel were used. Since the BHTP CHF correlation needs to be a part of the NRC-approved criteria and methodology used by Framatome ANP, Reference 4 has been revised in Reference 5 to incorporate the new correlation.

Figure 3 shows the respective CHF design limit, SDL, and TDL to reflect the use of the BHTP correlation. The Cycle 14-specific safety limit line shown in Figure 2 reflects the DNB predictions for a full core of Mark-B-HTP fuel and a TDL of [ ]. One can see in Figure 2 that

the Cycle 14-specific safety limit line, although more restrictive than the Cycle 13-specific safety limit line, still remains bounded by the ITS Figure 2.1.1-1 safety limit line. As a result, the ITS safety limit line is retained for Cycle 14.

REFERENCES

1. BAW-10156-A, Rev.1, "LYNXT Core Transient Thermal-Hydraulic Program", B&W Fuel Company, Lynchburg, Virginia, August 1993.
2. BAW-10187P-A, "Statistical Core Design for B7W-Designed 177FA Plants", B&W Fuel Company, Lynchburg, Virginia, March 1994.
3. BAW-10143P-A, "BWC Correlation of Critical Heat Flux", Babcock & Wilcox, Lynchburg, Virginia, April 1985.
4. BAW-10179P-A, Rev. 4, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses", August 2001.
5. BAW-10179P, Rev. 5, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses", December 2002.
6. BAW-10241P, "BHTP DNB Correlation Applied With LYNXT", Framatome ANP, Lynchburg, Virginia, December 2002.

REQUEST 2: Explain how the mixed core DNB penalty has been determined using LYNXT for a conservative configuration of Mark-B-HTP and co-resident fuel designs.

EXPLANATION

First, it might be beneficial to explain the LYNXT modeling used for the determination of the DNB-based safety limit lines and limiting transient analyses. The LYNXT code is approved for DNB predictions under steady-state and transient conditions using single-pass multi-channel modeling. The NRC approval and capabilities of LYNXT are available in Reference 1.

For CR-3 Cycle 14, Framatome ANP modeled a full core with 177 Mark-B-HTP fuel assemblies (using a 1/8 core symmetry model with LYNXT) as shown in Figure 1. This model is composed of 12 channels. The limiting, or hot, bundle is modeled at the core center.

Channels 1 through 10 represent individual subchannels. Channel 11 represents the remainder of the hot bundle. Channel 12 represents the remainder of the core. The limiting location for the placement of the hot pin is Rod 6 for the BHTP correlation (Reference 2). The limiting fuel rod is modeled as a 1.800 $F_{\Delta H}$ with a 1.65 symmetric axial power shape.

The CR-3 Cycle 14-specific safety limit lines, discussed in the explanation to REQUEST 1, were determined using this model and a DNB design limit of [ ] (TDL) with the BHTP correlation. If the transition core DNB penalty and any other cycle-specific penalties are smaller than the DNB margin between the [ ] TDL and the [ ] SDL (see Figure 3 in EXPLANATION 1), then the analysis bounds the Mark-B-HTP full core configuration and the transition cores.

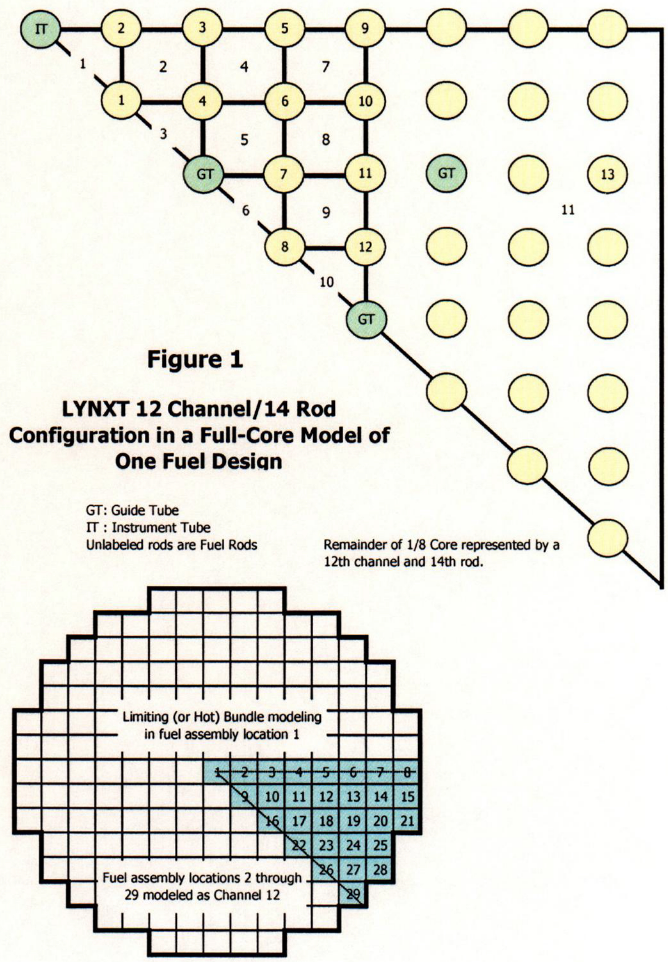


Figure 1

LYNXT 12 Channel/14 Rod Configuration in a Full-Core Model of One Fuel Design

The calculation of the transition core DNB penalty will now be discussed.

The fresh Mark-B-HTP fuel has slightly different hydraulic characteristics than the resident Mark-B10 fuel design at the lower end fitting and at all the spacer grids. Hydraulic testing was used to determine the hydraulic form loss coefficients for the assembly hardware for the Mark-B-HTP and Mark-B fuel designs.

The LYNXT model for the transition core is composed of 64 channels and 60 rods as shown in Figure 2. Again, the limiting fuel rod is modeled as a 1.800 $F_{\Delta H}$ with a 1.65 symmetric axial power shape at Rod 6 when the hot bundle is modeled as a Mark-B-HTP fuel assembly and the

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DNB performance is predicted using the BHTP correlation. For cases where the hot bundle is modeled as a Mark-B10 fuel assembly, the limiting fuel rod, 1.800 $F_{\Delta H}$ with a 1.65 symmetric axial power shape, is placed at Rod 2 for DNB predictions using the BWC CHF correlation (Reference 3). Framatome ANP has determined the limiting hot rod location for the respective CHF correlations by moving the hot rod throughout the hot bundle to isolate the most severe DNB response. This action assures the most conservative DNB prediction for the design power distribution (1.800 $F_{\Delta H}$ with a 1.65 symmetric axial power shape at the hot rod) for each fuel design.

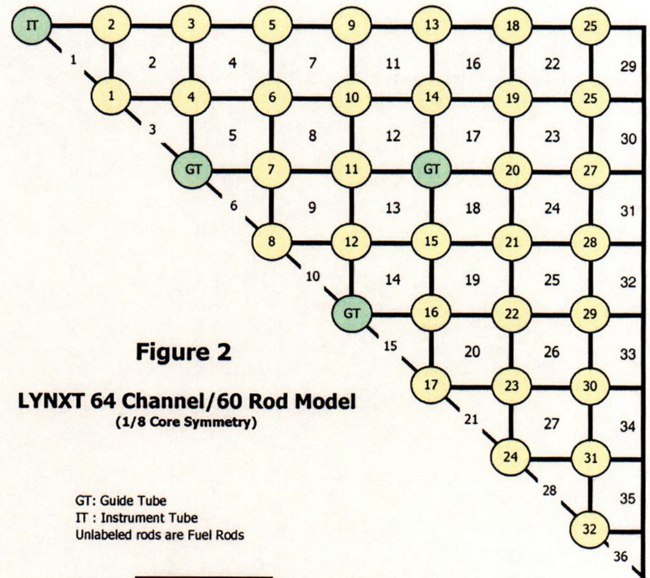


Figure 2

LYNXT 64 Channel/60 Rod Model
(1/8 Core Symmetry)

Two different core configurations were examined to bound the DNB performance for the fresh Mark-B-HTP fuel and the resident Mark-B10 fuel designs. Using this technique to conservatively address the transition core DNB penalty assures the transition core analyses remain bounding and applicable even for emergency core redesigns using a minimum of 65 Mark-B-HTP fuel assemblies in the core.

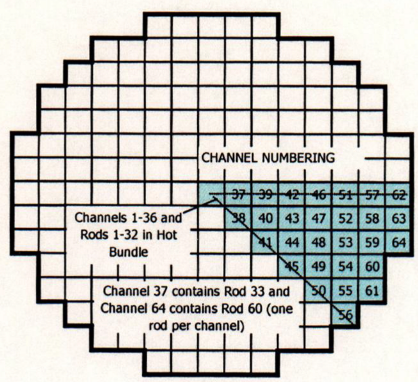
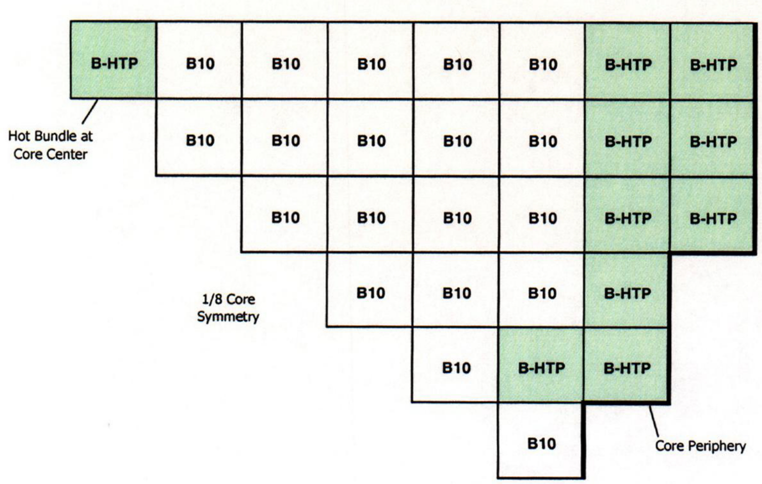


Figure 3 shows the core configuration that accentuates the flow diversion out of the Mark-B-HTP hot bundle. By conservatively placing all the lower pressure drop Mark-B10 fuel around the limiting Mark-B-HTP hot bundle, the most conservative DNB penalty can be determined for a limiting Mark-B-HTP fuel assembly. It should be noted that the core configuration model for CR-3 is composed of 65 Mark-B-HTP fuel assemblies and 112 Mark-B10 fuel assemblies. Since the transition core DNB penalty analysis for CR-3 was performed before the Cycle 14 final fuel cycle design was established, a conservatively low number of Mark-B-HTP fuel assemblies were used in the evaluation. The core is scheduled to be loaded with 85 Mark-B-HTP fuel assemblies for Cycle 14. The use of only 65 Mark-B-HTP maximizes the amount of coolant diverted from the limiting Mark-B-HTP fuel assembly thereby reducing the DNB performance within the hot bundle.

Figure 3

Conservative Transition Core Configuration for Mark-B-HTP Hot Bundle
(Number of Mark-B-HTP Modeled is less than Actual number in Core)



The transition core DNB penalty associated with the Mark-B-HTP hot bundle was computed by determining the difference

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between the DNB performance of the transition core, represented in Figure 3, and the DNB performance obtained using a full core model of Mark-B-HTP fuel assemblies. Both LYNXT models used the 64 channel/60 rod LYNXT model as shown in Figure 2.

The penalty is computed as follows.

Transition Core DNB Penalty for Mark-B-HTP Hot Bundle	=	DNB Prediction for Full Core of Mark-B HTP Fuel	-	DNB Prediction for Mark-B-HTP Hot Bundle in a Bounding Transition Core Configuration

If the DNB prediction for a Mark-B-HTP hot bundle is lower, for a given statepoint condition, in the transition core model than in a full core model of Mark-B-HTP fuel, then the DNB penalty is positive indicating the transition situation is not bounded by the DNB analysis based on a full core of Mark-B-HTP fuel. The transition core DNB penalty is determined by examining this DNB difference for numerous operating conditions (~100). The conditions include steady-state cases at the cycle-specific safety limit line evaluated across a wide range of axial power distributions (highly inlet skewed to highly outlet skewed). Even the limiting Condition I/II DNB-transient is examined across a wide range of axial power distributions with both models to quantify a DNB difference. Once all the operating conditions are evaluated, the maximum positive penalty is then assessed against the Mark-B-HTP fuel assembly.

Figure 4

Thermal Design Limit (TDL) Basis for the Mark-B-HTP Fuel Design in CR-3 Cycle 14

[ ]

As long as the maximum positive DNB penalty is smaller than the DNB margin reserved between the TDL and SDL shown in Figure 4 for the Mark-B-HTP fuel design, then the Mark-B-HTP full core DNB analysis of record is bounding and applicable for the Cycle 14 transition core. Using the procedure described above, the transition core DNB penalty for the Mark-B-HTP was found to be [ ] DNB points (where 1 DNB point =0.01) when using the conservative core configuration show in Figure 3. Sufficient margin has been reserved between the TDL and SDL to offset this transition core penalty.

This same procedure is performed for the second core configuration where the hot bundle is the resident fuel design, or Mark-B10. In Figure 5 one can see the placement of the Mark-B10 fuel design into the hot bundle location. In order to maximize the diversion of flow out of the Mark-B10 hot bundle, the hot bundle is surrounded with other Mark-B10 fuel assemblies (having a

lower pressure drop than the Mark-B-HTP fuel). The placement of Mark-B-HTP fuel adjacent to or near the Mark-B hot bundle would reduce the amount of coolant being diverted from the Mark-B10 hot bundle.

The transition core DNB penalty associated with the Mark-B10 hot bundle was computed by determining the difference between the DNB performance of the transition core, represented in Figure 5, and the DNB performance obtained using a full core model of Mark-B10 fuel assemblies. Both LYNXT models used the 64 channel/60 rod LYNXT model as shown in Figure 2.

The penalty is computed as follows.

Transition Core DNB Penalty for Mark-B10 Hot Bundle	=	DNB Prediction for Full Core of Mark-B10 Fuel	-	DNB Prediction for Mark-B10 Hot Bundle in a Bounding Transition Core Configuration

If the DNB prediction for a Mark-B10 hot bundle is lower, for a given statepoint condition, in the transition core model than in a full core model of Mark-B10 fuel, then the DNB penalty is positive indicating the transition situation is not bounded by the DNB analysis based on a full core of Mark-B10 fuel. After determining the DNB difference for the ~100 operating conditions with various axial power distributions, it was concluded that no DNB penalty was necessary for the Mark-B10 resident fuel design. In every case more flow was passing through the Mark-B10 hot bundle as a result of the Mark-B-HTP fuel in the core than would pass through the hot bundle for a full core of Mark-B10 fuel.

Figure 5

Conservative Transition Core Configuration for Mark-B Hot Bundle
(Number of Mark-B-HTP Modeled is less than Actual number in Core)

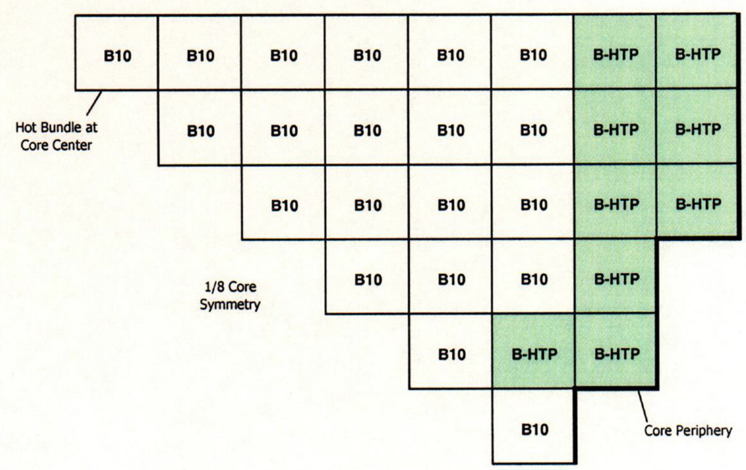

Figure 7

Transition Core DNB Penalty as a function of the Number of Mark-B-HTP Fuel Assemblies in the CR-3 Core

[ ]

The above described methodology results in a

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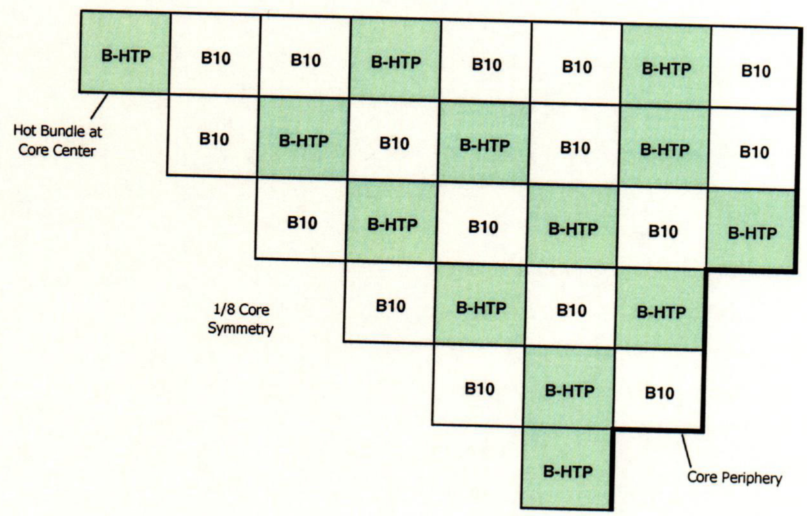
[ ] DNB point transition core penalty that will be applied to the Mark-B-HTP fuel design. No transition core DNB penalty need be assessed against the Mark-B10 fuel design for Cycle 14.

The above discussion addresses the analyses that quantified the [ ] DNB point penalty. In addition to the above analysis process, Framatome ANP performed more extensive transition core analyses to better understand the sensitivity of the transition core penalty to such things as: 1) the number of Mark-B-HTP fuel assemblies in the core and 2) the actual core configuration planned for CR-3 Cycle 14. Using the 64 channel/60 rod LYNXT model shown in Figure 2, Framatome ANP determined the transition core DNB penalty for various transition scenarios of Mark-B-HTP fuel in the core based on ~100 operating conditions for each scenario. In Figure 6 the transition core DNB penalty is shown as a function of the number of Mark-B-HTP fuel assemblies in the core using the conservative approach of surrounding the Mark-B-HTP hot bundle with Mark-B10 fuel. The resulting sensitivity shows the transition core penalty decreases approximately 1 DNB point for every 8 Mark-B-HTP fuel assemblies added to the core.

The actual planned core configuration for CR-3 Cycle 14, shown in Figure 7, was also examined using the 64 channel/60 rod LYNXT model. Cycle 14 is scheduled to utilize 85 Mark-B-HTP fuel assemblies. The transition core penalty for the actual core configuration is only [ ] DNB points. Therefore, the [ ] DNB point transition core penalty being adopted in the CR-3 Cycle 14 DNB analyses reflects [ ] DNB points of conservatism attributed to surrounding the Mark-B-HTP hot bundle with Mark-B10 fuel, and [ ] DNB points of conservatism attributed to assuming only 65 Mark-B-HTP fuel assemblies in the analysis of record.

Figure 7

Planned Core Configuration for CR-3 Cycle 14



Summarizing, the transition core DNB penalty that will be used in the CR-3 Cycle 14 analysis of record will be [ ] DNB points. This penalty has been shown to conservatively bound the planned Cycle 14 core configuration and will remain bounding and applicable for Cycle 15 when more Mark-B-HTP fuel assemblies will be introduced into the CR-3 core. The [ ] DNB point penalty for Cycle 14 will be offset by the DNB margin retained in the TDL value of [ ] shown in Figure 4.

REFERENCES

1. BAW-10156-A, Rev.1, "LYNXT Core Transient Thermal-Hydraulic Program", B&W Fuel Company, Lynchburg, Virginia, August 1993.
2. BAW-10241P, "BHTP DNB Correlation Applied With LYNXT", Framatome ANP, Lynchburg, Virginia, December 2002.
3. BAW-10143P-A, "BWC Correlation of Critical Heat Flux", Babcock & Wilcox, Lynchburg, Virginia, April 1985.

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REQUEST 3: Explain the Cycle 14-specific DNB results obtained using the BHTP DNB correlation.

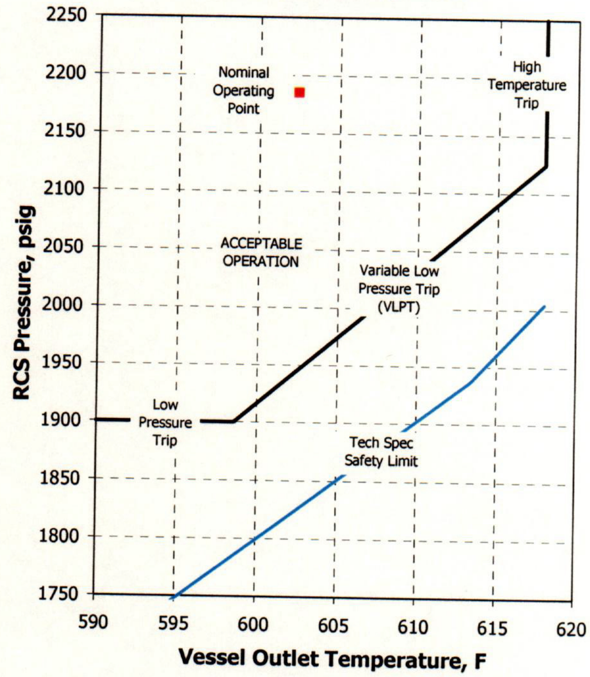
EXPLANATION

The DNB analyses for CR-3 Cycle 14 utilize the safety criteria and methodology identified in Reference 1. The DNB analyses utilize the BHTP CHF correlation (Reference 2) which is included by reference in Reference 1. Both References 1 and 2 are under NRC review.

For hot pin DNBR predictions that are less than the Thermal Design Limit (TDL), the hot fuel rod is assumed to have failed. The Cycle 14-specific safety limit lines, discussed in EXPLANATION 1, have been established such that no operating condition within the allowable pressure-temperature envelope will have DNB predictions below the TDL. The pressure-temperature envelope is defined by the trip functions, some of which, are shown in Figure 1.

Figure 1

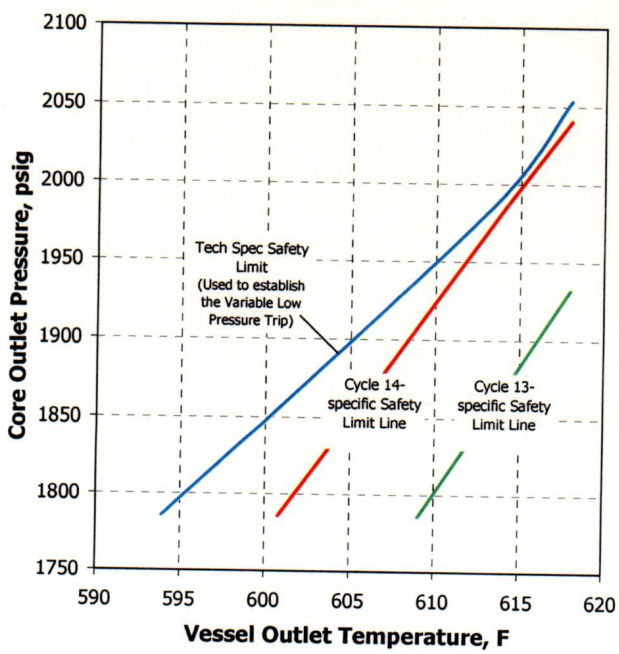
Pressure-Temperature Trip Limits and the Tech Spec Safety Limit



The Cycle 14-specific safety limit line shown in Figure 2 is based on a TDL of [ ]. This TDL value adequately covers the transition core DNB penalty discussed in EXPLANATION 2. The TDL is also used as the DNBR criterion for safety analysis events. Transient analyses performed for CR-3 Cycle 14 show acceptable DNBR consequences. Framatome ANP evaluations show the DNB limiting Condition I/II events for CR-3 have minimum DNBR predictions greater than the TDL of [ ] for BHTP. The predictions below are based on LYNXT predictions using a full core model of Mark-B-HTP fuel.

Figure 2

Cycle 13-specific and Cycle 14-specific DNB-Based Safety Limit Lines Compared to the Conservative Tech Spec Safety Limit



One Pump Coastdown : [ ] BHTP
Four Pump Coastdown: [ ] BHTP

Since the minimum DNBRs are greater than the TDL, no fuel failure is predicted. Substantial DNB margin exists between these limiting events and the TDL.

The DNB limiting Condition III event, the locked rotor, is predicted to have a minimum DNBR of [ ]. Since the minimum DNBR is greater than the TDL, no fuel failure is

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predicted. The ejected rod event (Condition IV) assessment is dependent on the DNB performance of the core in determining the magnitude of fuel that is predicted to have failed. Analyses indicate the TDL must be equal to [ ] or lower for the Cycle 14 control rod ejection event to remain bounded by the assumption of the CR-3 alternate source term (AST) dose evaluations. Since this DNB prediction is less than the [ ] TDL used in establishing all other DNB-based limits, unused DNB margin within the TDL of [ ] will be used to offset the [ ] DNB point deficit in the control rod ejection event analysis to preserve the applicability of the AST dose evaluations for CR-3.

Figure 3

Utilization of the DNB Margin Within the Thermal Design Limit (TDL) for CR-3 Cycle 14

[ ]

Figure 3 shows the anticipated treatment of the DNB margin within the TDL of [ ]. Note that [ ] DNB points of DNB margin is preserved within the TDL even after offsetting the conservatively derived transition core DNB penalty and the control rod ejection event DNB margin deficit.

The DNB performance of the Mark-B-HTP and Mark-B10 fuel in the CR-3 Cycle 14 core is predicted to yield acceptable results for steady-state and transient conditions.

REFERENCES

1. BAW-10179P, Rev. 5, "Safety Criteria and Methodology for Acceptable Cycle Reload Analyses", December 2002.
2. BAW-10241P, "BHTP DNB Correlation Applied With LYNXT", Framatome ANP, Lynchburg, Virginia, December 2002.