Duke Energy Company	Oconee 1, 2, 3	The B&W Owners Group	AmerGen Energy Company, LLC	TMI-1
Entergy Operations, Inc.	ANO-1		FirstEnergy Nuclear Operating Company	D-B
Florida Power Corporation	Crystal River 3		Framatome ANP	

Working Together to Economically Provide Reliable and Safe Electrical Power

September 21, 2004
NRC:04:050
OG:04:1854

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Request for Amendment of Safety Evaluation for Preliminary Safety Concern (PSC) 2-00

Ref.: 1. Letter, Herbert N. Berkow (NRC) to James F. Mallay (FANP), "Evaluation of Framatome ANP Preliminary Safety Concern (PSC) 2-00 Relating to Core Flood Line Break and Operator Action Time," April 10, 2003. (Tac No. MA9973)

The NRC issued a safety evaluation concerning Framatome ANP Preliminary Safety Concern (PSC) 2-00, which addresses the core flooding line break and operator action times needed to trip the reactor coolant pumps (Reference 1). This safety evaluation included a condition that each B&W plant licensee must demonstrate that the M3 pump degradation curve is conservative for modeling its reactor coolant pumps.

In response to this condition in the safety evaluation, the B&WOG is providing additional information in the attachment to this letter to demonstrate that the M3 RCP degradation curve is conservative for all B&W plants. Based on this demonstration, the B&WOG requests that the NRC issue a new or revised safety evaluation. We request that the new or revised safety evaluation acknowledge the acceptability of the M3 RCP degradation curve for all B&W plants and remove the condition that each B&W plant licensee submit a justification to that effect.

Very truly yours,

James F. Mallay, Director
Regulatory Affairs

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Attachment A

Generic Justification for Use of the

M3 Two-Phase RCP Degradation Curve for

Pumps-On SBLOCA Applications on a B&W-Designed Plant

Attachment A Table of Contents

List of Tables

List of Figures

1. Background

The NRC Safety Evaluation on PSC 2-00 (Reference 1) included a contingency that requires the licensees of the B&W plants to establish that the M3-modified two-phase reactor coolant pump (RCP) degradation multiplier is conservative for each licensee's plant when applied with the BWNT LOCA evaluation model (EM), which is based on the RELAP5/MOD2-B&W (RELAP5) code. In response to this contingency, justification for application of the M3-modified two-phase RCP degradation multiplier to the RCPs in operation at each of the operating B&W plants is presented.

The evaluation of the consequences of continued RCP operation for up to one or two minutes in a cold leg pump discharge small-break loss-of-coolant accident (SBLOCA) with break sizes between 0.3- and 0.75-ft^2 resulted in peak cladding temperatures (PCTs) that are higher than the historical analyses that considered RCP trip coincident with a loss of offsite power triggered by reactor trip. This discovery became the subject of PSC 2-00, which also determined that the PCTs further increased when less two-phase RCP degradation was modeled. Less two-phase RCP degradation in the LOCA analyses results in the prediction of higher RCP head that keeps the reactor coolant system (RCS) fluid more homogeneous such that additional liquid is discharged out of the break. The increased liquid loss results in lower reactor vessel mixture levels and higher PCTs. A summary of the evaluation of PSC 2-00 for the B&W plants is contained in Reference 2, which was transmitted to the NRC via Reference 12.

Framatome ANP provided a comparison of a minimum, average and maximum RCP dimensionless two-phase head degradation multiplier, which included the M3-modified, RELAP5-default, and M1 curves, in the submittal to the NRC (Figure 5-5 of Reference 2). Although FANP compared these models to available RCP test data to ensure that the curves did represent an applicable bound, this additional information was not included in the submittal. This additional information supplements the information provided to the NRC via Reference 2.

2. Purpose and Objective

A comparison of the M3-modified, RELAP5-default, and M1 two-phase RCP degradation multipliers was made with applicable RCP two-phase performance data. The results were reviewed to ensure that the data is applicable to the conditions expected for the cold leg pump discharge SBLOCAs in the range of 0.3 to 0.75-ft^2. This review supports the conclusion that the M3-modified curve is a representative lower (less degradation) bound of the expected two-phase RCP degradation multiplier and is applicable to the RCPs currently in operation at the B&W plants when applied to the BWNT LOCA EM as described herein.

The objective of this report is to provide justification for the removal of the contingency contained in the Safety Evaluation Report (SER) for PSC 2-00 related to the M3-modified RCP degradation multiplier.

3. RCP Modeling in RELAP5

Section 2.1.5.2 of the RELAP5 topical report (Reference 3) provides a detailed description of the RCP modeling methodology for RELAP5/MOD2-B&W. The model as applied to determining the transient RCP head for application in the BWNT LOCA EM is described briefly to facilitate the discussion of the two-phase degradation multiplier.

The two-phase RCP homologous head is calculated by the following equation (Equations 2.1.5-8 from Reference 3).

$$H = H_{1\phi} - M_h(\alpha_g) * (H_{1\phi} - H_{2\phi}),$$

The focus of this investigation is the affect of the two-phase degradation multiplier, $M_h(\alpha_g)$, on the transient RCP performance with pumps powered. The results of the PSC 2-00 analyses show that forward flow is maintained in the cold legs for the majority of the time that the pumps remained powered. In this case, the speed ratio, α, remains greater than the flow ratio, ν, ($\nu/\alpha < 1.0$ is HAN octant), and the generic two-phase RCP homologous head equation can be rewritten as,

$$\frac{h}{\alpha^2} = \frac{h}{\alpha^2}\bigg|_{1\phi} - M_h(\alpha_g) * \left(\frac{h}{\alpha^2}\bigg|_{1\phi} - \frac{h}{\alpha^2}\bigg|_{2\phi} \right),$$

where the definition of the terms and source of data are described below.

Term	Description	Source [1]
α	RCP Speed Normalized to Rated Speed	Calculated by RELAP5
ν	Volume Flow normalized to Rated Flow	Calculated by RELAP5
$\left(\frac{h}{\alpha^2}\right)$	Speed Normalized Head	Calculated by RELAP5
$\frac{h}{\alpha^2}\Big\|_{1\phi}$	Single-phase RCP Homologous Data (HAN) Input as a Function of $\frac{\nu}{\alpha}$.	Input to RELAP5 BWNT LOCA EM: RCP-Type Specific
$\left(\frac{h}{\alpha^2}\Big\|_{1\phi} - \frac{h}{\alpha^2}\Big\|_{2\phi}\right)$	Two-phase Fully Degraded Head Difference term (HAN) Input as a Function of $\frac{\nu}{\alpha}$.	Input to RELAP5 BWNT LOCA EM: RELAP5-default (Semiscale)
$M_h(\alpha_g)$	Two-phase RCP Degradation Multiplier Input as a Function of Void Fraction.	Input to RELAP5 *Evaluated Herein* *(M1, RELAP5-default, M3-Modified)*

[1] It should be noted that the "RELAP5-default" terminology applies to both the two-phase fully degraded head difference and the void-dependent two-phase multiplier. This investigation is only concerned with the void-dependent two-phase multiplier.

The RCP vendors for the B&W plants are Bingham, Byron-Jackson, and Westinghouse. Pump-specific single-phase homologous data for all eight octants were developed from the vendors single-phase four-quadrant pump performance maps. The RELAP5-default two-phase head difference curves, which are the difference between the single-phase and fully-degraded homologous head values, were developed for RELAP5 using data from the Semiscale pump tests.

Section I.C.6 of Appendix K to 10 CFR 50 requires that "The pump model for the two-phase region shall be verified by applicable two-phase pump performance data." Although the B&W plants currently are not licensed to the Standard Review Plan (SRP), Section 15.6.5 III.4.f of the SRP states that the "analysis conservatively addresses the operation of the reactor coolant pump." The original development of the BWNT LOCA EM RCP modeling philosophy (Reference 4) complies with these statements by performing sensitivity studies with two-phase RCP characteristics developed from the Semiscale pump performance test data. These EM studies evaluated the two-phase operational differences of the various RCPs in use at the B&W plants with application of a representative upper bound (M1), lower bound (M3-modified), or an average "general-use" (RELAP5-default) void-fraction dependent head multiplier curves (shown in Figure 5). In each case, the resulting RCP performance is representative of the RCPs in operation at the plants. The RCP performance application is regarded as conservative because the model selected comes from the application that gives the highest PCT from the evaluation of the upper-bound, average, and lower-bound curves.

The application of representative bounds was utilized in lieu of quantification of the two-phase operating characteristics of each RCP type. Because the SBLOCA analyses presented in the EM considered an immediate RCP trip, the pump degradation multiplier selected was of little to no consequence. Since similar PCTs would have been predicted with the either the upper bound, lower bound or the general-use curves with immediate RCP trip, the general-use RELAP5-default degradation multipliers were specified in the BWNT LOCA EM for SBLOCA applications.

With the initiation of PSC 2-00, and analysis of the SBLOCA transients with continued RCP operation, the EM sensitivity studies on RCP degradation were repeated. These studies considered the upper and lower bound two-phase degradation multipliers (M1 and M3-modified). This is consistent with the LBLOCA RCP degradation studies presented in Section A.2.7 of Volume I of the BWNT LOCA EM (Reference 4). Based on the previous RCP degradation studies, the multiplier that provided the most-conservative analysis results was applied to the plant-specific SBLOCA application analysis. The most-conservative analysis results were obtained with application of the M3-modified (i.e. minimum) two-phase degradation multiplier. Since representative bounds of the potential two-phase performance were established, no further characterization of the two-phase degradation multipliers against test data was performed as part of the EM studies or the PSC 2-00 studies.

Additional information on the applicability of the M3-modified two-phase degradation multiplier to the RCPs in operation at the B&W plants is provided in the remainder of this attachment. This additional information is provided to justify removing the contingency on the use of the M3-modified two-phase degradation multiplier for application to SBLOCA analyses with the BWNT LOCA EM.

4. Determination of Applicable RCP Test Data

In the 1970's, EPRI supported a comprehensive program to study pump two-phase performance in order to understand the performance characteristics of pumps under accident conditions. Some of the pump tests that were performed are summarized in Table 1.

Table 1: Summary of RCP Test Data

Test	Pump Type	Fluid Condition	Test Description	Reference
B&W 1/3 Scale	Bingham	Air/Water	P = 20-110 psia α_g = 0.0 – 0.9	Ref. 9
CE 1/5 Scale	Byron Jackson	Steam/Water	P = 14-1200 psia α_g = 0.0 – 1.0	Ref. 5 and 10
Semiscale (ANC)	Lawrence	Steam/Water	P = 1.38-6.2 MPa = 200-900 psia α_g = 0.0 – 0.99	Ref. 7
Creare 1/20 Scale	Byron Jackson	Air/Water & Steam/Water	P = <90 psia (Air) = 400 psia (Steam) α_g = 0.0 – 1.0	Ref. 8
MIT Small Scale	Rotor Test	Air/Water & Freon	P = 40 psia (Freon) = 65 psia (Water) α_g = 0.1 – 0.9	Ref. 11

Together, the test results from the two-phase pump performance program provided invaluable information related to the performance of RCPs in single-phase and two-phase degraded conditions. This information led to the formulation of the RCP modeling contained in the current thermal hydraulic computer codes, including RELAP5/MOD2-B&W. The results of the studies also provided insight to the important parameters that define similarity between the pumps and those conditions which are important for determining the RCP performance.

The results of the studies support the application of the homologous pump performance model presented in Section 3. Application of the homologous models allow for normalization of RCP test data for the prediction of both partial-scale and full-scale RCP performance. Beyond RCP similarity, the most important parameters that must be matched in order to apply the homologous models correctly are fluid type, void fraction and pressure.

Because of the potential for uncertainties in the two-phase pump performance predictions, the BWNT LOCA EM prescribes that representative, to bounding, two-phase degradation modeling be considered in determination of the modeling that is applied to the LOCA analyses. This is consistent with Section I.C.6 of Appendix K to 10 CFR 50 and Section 15.6.5 III.4.f of the SRP. Nonetheless, the conditions applicable to the SBLOCA transient analyses with continued RCP operation were examined in greater detail and were demonstrated to be appropriate by showing that the analysis conditions were within the ranges of the most appropriate test data used in assessing the performance models. The first step was to extract the fluid conditions for the core flood tank (CFT) line break analysis, which was the subject of PSC 2-00. The pressure, void fraction, and flow versus speed ratios are listed in Table 2 for the time span during which the RCPs are powered. The maximum time span for RCP operation following initiation of a LOCA is based on manual RCP trip at one or two minutes (60 or 120 seconds) after loss-of-subcooling margin.

Table 2: Summary of SBLOCA Transient Conditions During RCP Operation

Pressure	800 – 2200 psia [1]
Void Fraction	0.0 – 1.0
Octant of Operation	Mostly HAN (momentary HVN in intact loop) $0.7 \leq \frac{v}{\alpha} \leq 1.0$
Flow per RCP	10,000 – 1,000 lbm/sec
RCP Type	Bingham, Byron-Jackson, Westinghouse Full Scale NSSS RCP
Fluid	Steam/Water

[1] The CFT line has a break area of 0.44-ft^2, and is one of the larger SBLOCA breaks. This case loses subcooling margin early and the RCPs are tripped near 120 seconds. The large break size results in a rapid depressurization, therefore pressures below this range are not of interest for the SBLOCA transient analyses.

Table 3: Summary of Specific Speeds for Various Pumps

RCP	Semiscale	CE 1/5	ONS-1	ONS-2	ONS-3	TMI-1	ANO-1	CR-3	DB-1
Specific Speed	926	4209	4357	4354	4354	4357	4351	4351	4339

The Semiscale and CE data span into the desired pressure and void fraction range. Similarity of the test pumps versus the B&W plant RCPs was reviewed as shown in Table 3. Although the Semiscale pump was widely tested under a variety of transient conditions characteristic of the LOCAs, with data taken at pressures up to 900 psia, the Lawrence pump is not a scaled model of a nuclear steam supply system (NSSS) RCP and has a considerably smaller specific speed than the B&W plant RCPs. The CE pump is a scaled model of a NSSS RCP, with a specific speed near that of the B&W plant RCPs. Since the CE pump is similar to the NSSS RCPs and the pressure range extends further into the SBLOCA transient range of interest, it is concluded that the best RCP two-phase pump performance data is obtained from the CE 1/5 scale data from References 5, 6 and 10. In addition, Reference 6 concluded that the steady-state pump performance data was applicable to transient situations, therefore the CE 1/5 scale steady-state data from Reference 5 was utilized in the evaluation.

A comparison of the CE 1/5 single-phase homologous head data to the B&W plant single-phase homologous head data is shown in Figure 1. The comparison shows the similarity in the homologous performance characteristics, especially in the HAN and HVN octants where the pump operates during the time span of interest, which further supports the application of the CE 1/5 RCP degradation study to the evaluation.

The CE 1/5 fully-degraded two-phase head difference is shown in Figure 2 based on the single-phase and fully-degraded head (80% void fraction). This is compared to the RELAP5-Default two-phase head difference model used with the BWNT LOCA EM in Figure 2. The comparison shows that the RELAP5-default model (based on the Semiscale tests) provides a greater fully degraded homologous head difference than the CE 1/5 test data. This larger head difference has the potential to reduce the generated head during two-phase conditions and make the calculated PCT results more favorable. However, the RCP single phase head curves combined with the two-phase head difference curves and the two-phase multiplier curve determines the pump head. This combination will be compared based on the investigations discussed in Section 5.

Figure 1: Comparison of CE 1/5 and B&W Plant Single-Phase Homologous Head

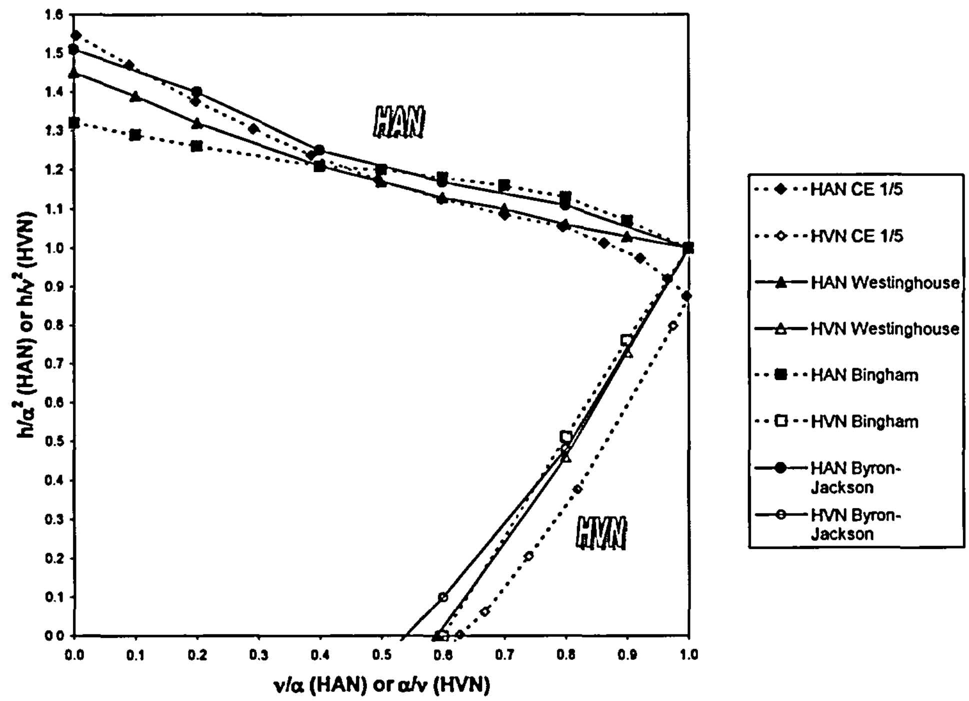
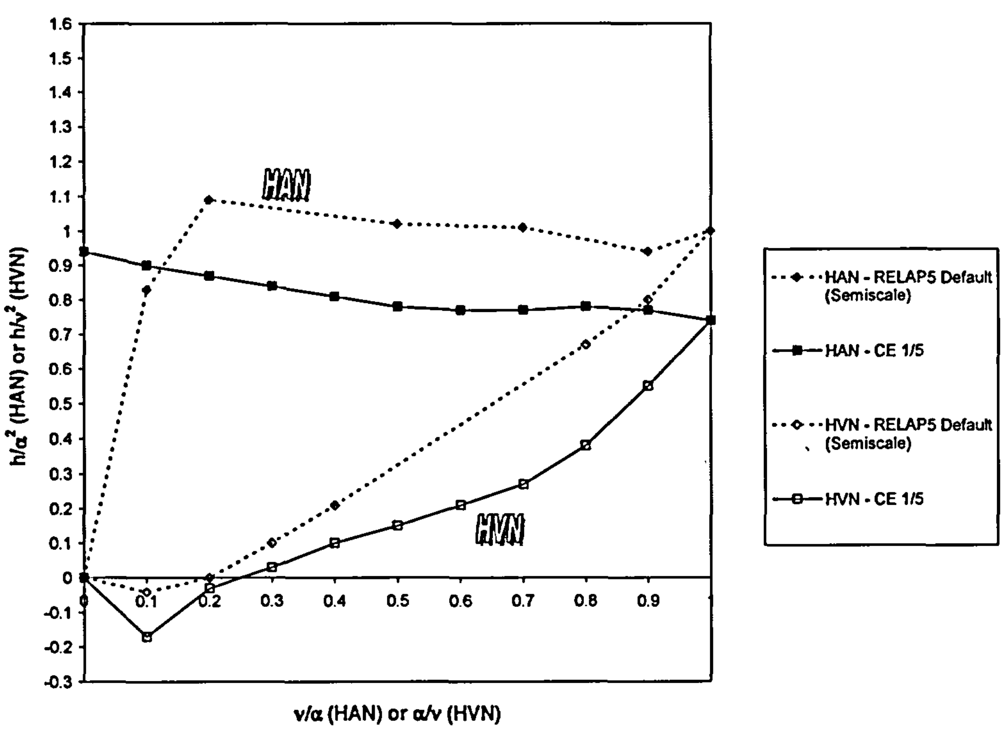


Figure 2: Comparison of RELAP5-Default and CE 1/5 Fully-Degraded Homologous Head Difference ($H_{1\phi} - H_{2\phi}$)



5. Investigation

A review of the CE 1/5 scale data has concluded that the two-phase RCP degradation is a strong function of void fraction and pressure. Although the RELAP5 RCP modeling methods include a term to account for the head degradation as a function of void fraction, there is no explicit treatment with respect to pressure. Since the LOCA is a depressurization transient, there is no one set of RCP inputs to RELAP5 that may realistically represent the RCPs at all times during the LOCA transient. Therefore, the BWNT LOCA EM evaluates an upper-bound, lower-bound and best-estimate representation of the RCP two-phase degradation in sensitivity studies and selects that which provides the most-conservative LOCA PCT results. Through the investigation of PSC 2-00, the M3-modified (lower-bound) two-phase degradation multiplier (function of void fraction) was shown to provide the most conservative LOCA PCT results.

The evaluation of the LOCA transient with continued RCP operation is summarized in detail in Reference 2. The loss of RCS liquid following a postulated LOCA results in RCS depressurization and the formation of steam voids in the system, which depend on the break location and the core energy flow paths that are established. A potentially limiting cold leg pump discharge (CLPD) break transient can quickly evolve to predominately steam conditions upstream of the break when the RCPs are lost by loss of offsite power (LOOP) at the time of turbine trip. With the RCPs de-energized, the reactor vessel vent valves (RVVVs) will open and pass core steam into the upper downcomer and CLPD region. Liquid remains pooled in the reactor vessel, cold leg pump suction (CLPS) piping, and some can be held up in the hot leg and steam generator tube regions if the mixture level in the vessel is above the hot leg spillunder elevation. The liquid remaining in the RCS after RCP trip offsets the core heat addition, and the amount of liquid remaining affects the time of core uncovering and the magnitude of the PCT.

If offsite power is available, the RCPs continue to operate during a LOCA until the operators trip them within one or two minutes after loss of subcooling margin (LSCM). With the pumps in operation, the RVVVs remain closed and the RCS liquid and steam in the RCS are well mixed. The liquid fraction upstream of the break location is higher with the RCPs operating and more liquid will be lost from the system than that for a similar case with the RCPs tripped. After the operators trip the RCPs, the liquid will separate from the steam and drain into the reactor vessel or CLPS piping. If the RCP operation stops at the time the system void fraction is roughly 0.7, then the core mixture level after the liquid drain down will coincide with roughly the top of the core. RCP trip at lower void fractions will not result in uncovering of the core at the time of trip. If the void fraction is greater than 0.7 at pump trip, the core will uncover and the cladding will heatup in the uncovered region of the core until the ECCS flows refill the core.

Continued RCP operation for up to two minutes for larger SBLOCAs has the potential to allow the system void fraction to increase above 0.7 and result in a calculated PCT that is higher than a similar case with RCPs tripped at LOOP. A higher RCP head will keep the RCS better mixed during RCP operation and will not let liquid separate from the steam in regions within the reactor vessel. While the status of the pump power is the most important parameter, the integrated performance of the RCP as the RCS voids has some bearing on the severity of the transient. A less degraded RCP will keep the RCS more homogeneous and discharge more liquid from the break than a pump that is more degraded. Through the investigation of PSC 2-00, the M3-modified (lower-bound) two-phase degradation multiplier (function of void fraction) was shown to represent a less degraded RCP and provide the most conservative LOCA PCT results. However, the NRC has requested (Reference 1) that the degradation multiplier be demonstrated to be representative of the RCPs in operation at the B&W plants.

The BWNT LOCA EM RCP model utilizes the B&W plant single-phase homologous RCP data and the RELAP5-default two-phase degradation difference with a choice of two-phase degradation difference curves (RELAP5-default, M1 and M3-modified). The degradation curve is selected via sensitivity studies. Although PSC 2-00 has determined that a conservative PCT calculation is obtained for larger SBLOCAs with continued RCP operation when using the M3-modified curve, the two-phase RCP head that is predicted by this combination of inputs is compared against the CE 1/5 scale test data to verify that the model is representative of the B&W plant RCPs. The CE 1/5 data is compared to the BWNT LOCA methods with both the RELAP5-default and M3-modified two-phase degradation multiplier curves.

Figure 3 shows that the BWNT LOCA methods that utilize the M3-modified two-phase RCP degradation multiplier with the RELAP5-default two-phase head difference provides a maximum RCP head when compared to the CE 1/5 data over a majority of void fractions from 0.0 to 1.0. For void fractions between 0.15 and 0.25, and pressures greater than 1200 psia, the M3-curve slightly under-predicts the expected RCP head. For the smallest break sizes, the RCP trip based on time after LSCM could occur with the system void fraction in this range. These break sizes will have the highest RCS pressures (greater than 1200 psia) with void fraction ranges where the M3-curve will produce slightly non-conservative head results when compared to the CE data. However, there is little degradation at these conditions and any small non-conservatism in head is inconsequential because the system liquid content is such that the core is continuously covered with a substantial amount of liquid remaining in the hot legs at the time of pump trip. Slightly larger break sizes will likely have RCP trip at higher void fractions and slightly lower RCS pressures. The M3-curve increases in conservatism as the void fraction increases above 0.25 at a pressure of 1200 psia. Above a void fraction of 0.25, or at pressures less than 1000 psia for any void fraction, the M3 curve is conservative relative to the CE data. The conservatism continues to increase as void fraction grows or pressure decreases, which would be the case for the largest SBLOCA cases. The integrated effect of application of the M3-curve to the break sizes that approach or predict core uncovering are conservative for the full range of voiding that is predicted.

From Table 2, the v/α parameter varies between 0.7 to 1.0 during the extended RCP operation period for a CFT line break (a potentially limiting break location when RCPs are allowed to run beyond the time of reactor trip). Therefore, the comparison shown in Figure 3 was recalculated for a v/α of 0.7 to cover the full range of expected RCP application. The two-phase RCP head determined by the BWNT LOCA methods with the M3-modified two-phase degradation multiplier at a v/α of 0.7, shown in Figure 4, is representative of, but slightly lower than, the expected head at high pressure (1000 psia) and void fractions between roughly 0.1 and 0.4 for all three B&W RCP types. In the range of void fractions greater than 0.4 and pressures less than 1000 psia, the M3-modified two-phase degradation multiplier predicts a RCP head equal or greater than that determined by the CE test. Review of the CFT line break transient results (void fraction and pressure) from PSC 2-00 indicate a best-estimate representation of the RCP would be predicted for the first minute of the LOCA. In this case, however, the system void fraction would not exceed 0.7 and core uncovering would not be predicted, such that conservatism in the head degradation is of little to no consequence. The void fraction continues to increase and the RCS pressure decreases during the second minute of the PSC 2-00 LOCA, during which time a conservative representation of the RCP head would be predicted.

Another type of comparison can be made that focuses more on the two-phase degradation multiplier term. When the expected CE 1/5 two-phase head is used as a "known" value and input to the two-phase head equation, a value for the two-phase degradation multiplier may be directly calculated for each set of B&W plant RCP single-phase homologous data combined with the RELAP5-default head difference table. (At this flow condition, the single-phase homologous data for each B&W plant RCP is equal to 1.0 and a single curve is representative of all of the B&W plants.)

The CE results at 1200, 1000, 850 and 480 psia are compared to the M3-modified, RELAP5-default (semiscale) and M1 two-phase degradation multipliers as shown in Figure 5. From the figure, the M3-modified curve represents a lower-bound of the two-phase degradation multiplier compared to the CE 1/5 data. As the pressure decreases, the M3-modified curve multipliers are much lower in comparison to the CE 1/5 data, thus increasing the conservatism of the RCP head prediction as the transient progresses. This comparison demonstrates the applicability of the M3-modified, M1, and RELAP5-default degradation multipliers to the NSSS RCPs, and further justifies that the M3-modified curve is a lower bound of the applicable test data.

These comparisons substantiate the conclusion that the BWNT LOCA EM RCP modeling with the M3-modified two-phase degradation multiplier provides a higher RCP head for potentially limiting SBLOCAs (as a function of depressurization) for the B&W RCPs compared to the CE 1/5 scale test data. As determined via the resolution of PSC 2-00 (Reference 2), the RCP performance is especially important in those cases where the system void fraction approaches or exceeds 0.70. For the PSC 2-00 cases, a higher RCP head predicted for the RCP with operation beyond the time of turbine trip provides the most conservative PCT consequences. For the smaller break SBLOCAs (<0.30-ft^2), the system voids much slower and the RCPs are tripped by one or two minutes into the accident. In the 0.25 to 0.70 fraction range, the RCP head prediction during continued RCP operation will not have a significant impact on the analysis results. For the smaller SBLOCA, the limiting PCT consequences are predicted with early RCP trip on LOOP coincident with turbine trip. The RCP degradation model used for a SBLOCA with RCPs tripped on LOOP has little to no bearing on the results. The M3-modified two-phase degradation curve is chosen when the RCPs are in operation because it provides a conservative PCT prediction for SBLOCA with operator action to trip the RCPs on LCSM. Based on the comparison to the CE 1/5 data, the M3-modified two-phase degradation curve is applicable to the RCPs in operation at the B&W plants.

Figure 3: Two-Phase Degraded Head (v/α=1.0)

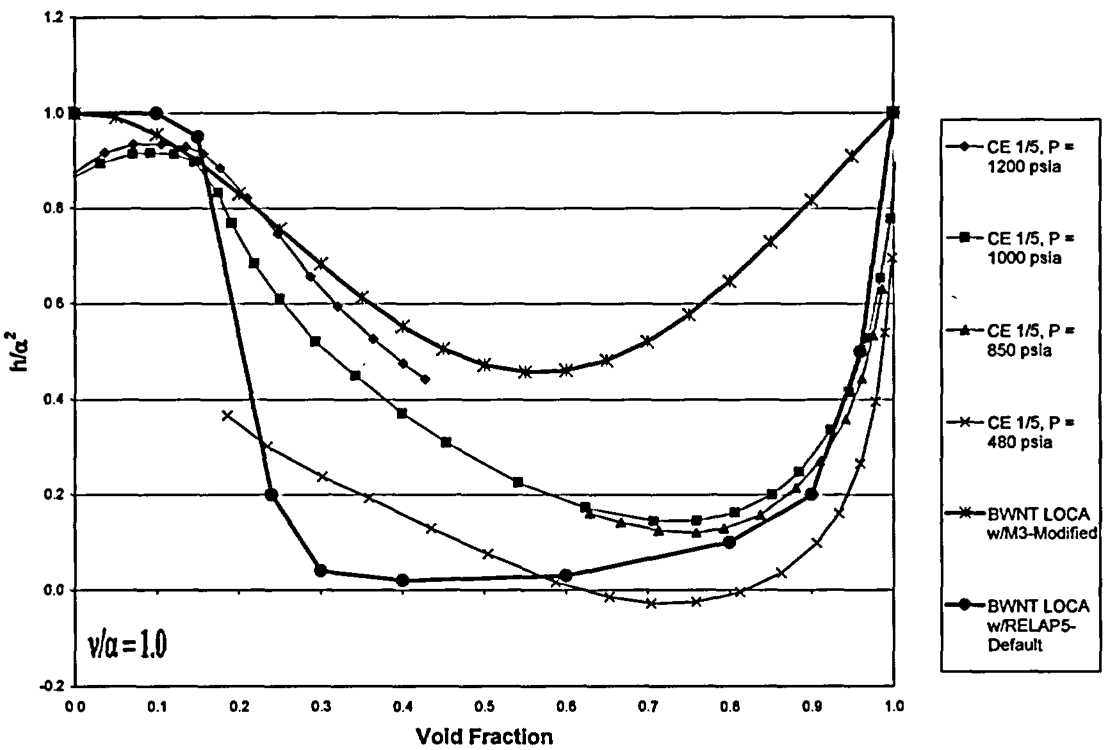


Figure 4: Two-Phase Degraded Head (v/α=0.7)

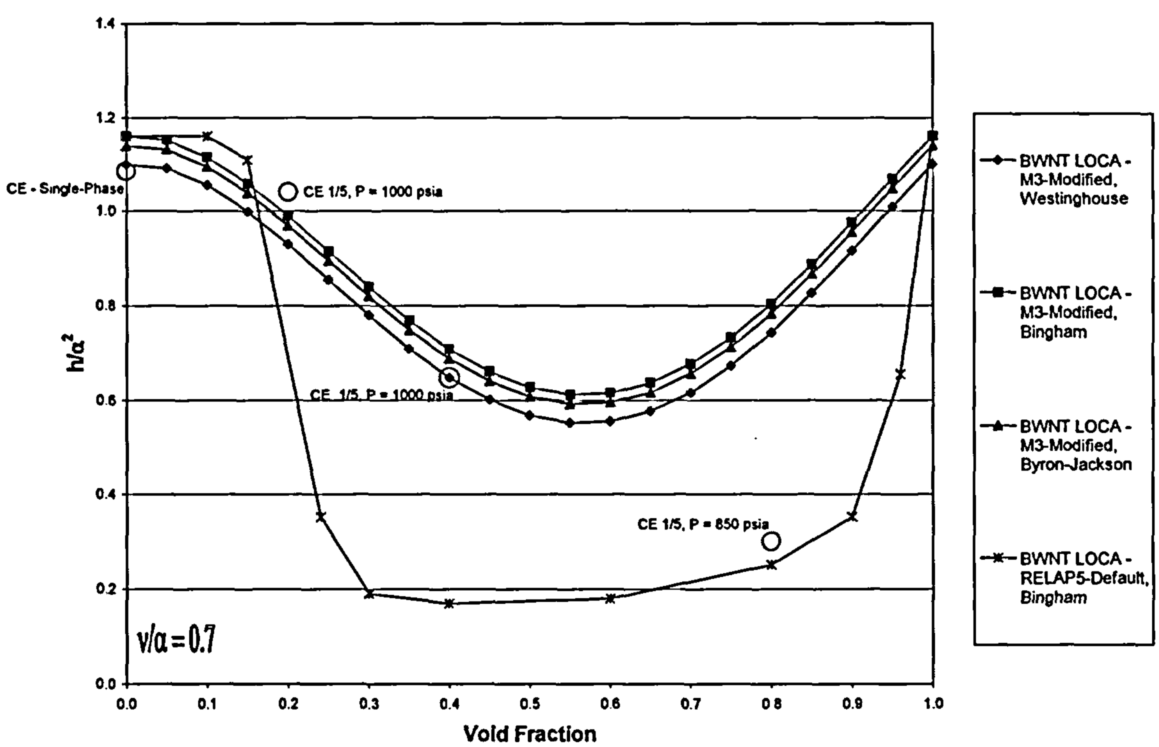
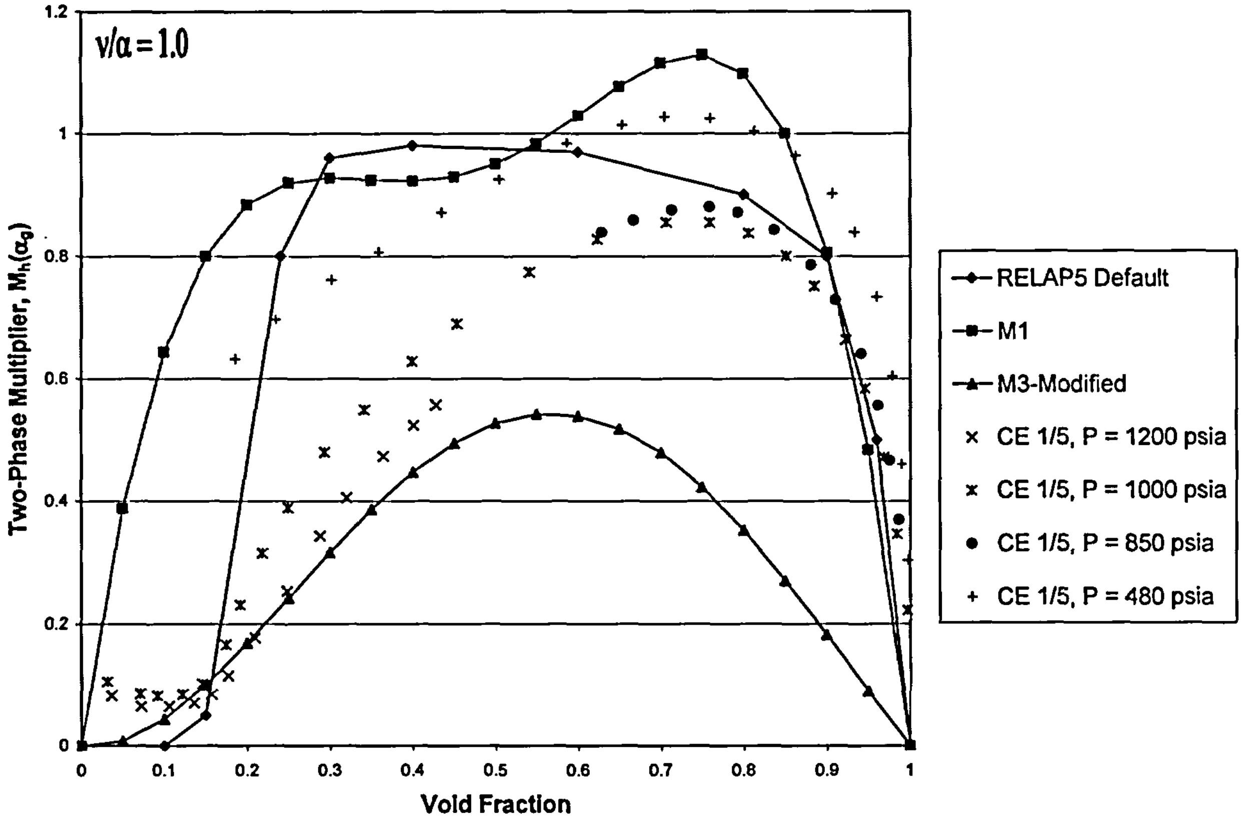


Figure 5: Two-Phase Degradation Multiplier Comparison (v/α=1.0)



6. Summary and Conclusions

The RCP performance predicted by RELAP5 with the M3-modified, RELAP5-default, and M1 two-phase RCP degradation multipliers were compared with applicable RCP two-phase performance data. A review of several two-phase RCP degradation studies revealed that the CE 1/5 scale RCP tests were the most representative of the B&W plant RCPs and the conditions that are expected during continued RCP operation in a SBLOCA transient for up to two minutes following the loss of subcooling margin.

Comparisons of both the final two-phase head and the degradation multiplier were provided for conditions that are expected during the SBLOCA transient (void fraction from 0.0 to 1.0, and v/α of 0.7 to 1.0). The M1, RELAP5-default, and M3-modified two-phase degradation multipliers were demonstrated to be representative of the expected RCP performance of the CE 1/5 scale pump. Further, the M3-modified curve was shown to be a lower-bound of the applicable test data and to over-predict the RCP head as the RCS pressure decreases.

These comparisons substantiate the conclusion that the BWNT LOCA EM RCP modeling with the M3-modified two-phase degradation multiplier provides a representative to higher RCP head (as a function of depressurization) for the B&W RCPs compared to the CE 1/5 scale test data. As determined via the resolution of PSC 2-00 (Reference 2), the RCP performance is especially important in those cases where the system void fraction approaches 0.70. For the PSC 2-00 cases, a higher RCP head predicted for the RCP with operation beyond the time of turbine trip provides the most conservative PCT consequences. For the smaller break SBLOCAs (<0.30-ft^2), the system voids much slower and the RCPs are tripped by one or two minutes into the accident. In the 0.25 to 0.70 fraction range, the RCP head prediction during continued RCP operation will not have a significant impact on the analysis results. For the smaller SBLOCA, the limiting PCT consequences are predicted with early RCP trip on LOOP coincident with turbine trip. The RCP degradation model used for a SBLOCA with RCPs tripped on LOOP has little to no bearing on the results. The M3-modified two-phase degradation curve is chosen when the RCPs are in operation because it provides a conservative PCT prediction for SBLOCA with operator action to trip the RCPs on LSCM. Based on the comparison to the CE 1/5 data, the M3-modified two-phase degradation curve is applicable to the RCPs in operation at the B&W plants.

Consistent with the current practice, the BWNT LOCA EM will utilize the following inputs for determining the RCP two-phase performance for LBLOCA and SBLOCA applications:

1) Plant-Specific single-phase homologous plant data
2) RELAP5-default two-phase head difference
3) Sensitivity study to determine the void-dependent two-phase degradation multiplier. The study will be based on the comparison of results with curves that range between the M1 and M3-modified curves, which have been demonstrated to be applicable to the RCPs in operation at the B&W plant types when used in combination with 1) and 2) above.

The conclusions generated are generic for application to the BWNT LOCA EM for the RCP types currently in operation at the B&W plants. Therefore, this information is being submitted to the NRC to serve as additional information to justify removing the contingency on the SER for PSC 2-00 (Reference 2).

7. References

1. NRC, Safety Evaluation, "Evaluation of Framatome ANP Preliminary Safety Concern (PSC) 2-00 Relating to Core Flood Line Break and Operator Action Time (TAC No. MA9973)," April 10, 2003.
2. FANP Document 51-5009856-00, "Summary of PSC 2-00 Analyses," 4/13/01.
3. FANP Topical Report BAW-10164PA-04, "RELAP5/MOD2-B&W – An Advanced Computer Program for Light Water Reactor LOCA and NON-LOCA Transient Analysis," 12/4/02.
4. FANP Topical Report BAW-10192PA-00, "BWNT LOCA – BWNT Loss-of-Coolant Accident Evaluation Model for Once-Through Steam Generator Plants," 6/98.
5. EPRI NP-1556, Volume 2, Project 301 "Pump Two-Phase Performance Program, Volume 2: Steady-State Tests," September 1980.
6. EPRI NP-1556, Volume 4, Project 301 "Pump Two-Phase Performance Program, Volume 4: Comparison of Steady-State versus Transient Test Results," September 1980.
7. NUREG/CR-4945, "Summary of the Semiscale Program (1965-1986)," July 1987.
8. EPRI NP-2379, "Model Pump Performance Program – Data Report," May 1982.
9. EPRI NP-135, "One-Third-Scale Air-Water Pump Program Test Program and Pump Performance," July 1977.
10. EPRI NP-1556, Volume 7, Project 301 "Pump Two-Phase Performance Program, Volume 7: Test Facility Description," September 1980.
11. EPRI NP-677, "Analytical Models and Experimental Studies of Centrifugal-Pump Performance in Two-Phase Flow," May 1979.
12. FANP Letter FANP-01-988, D. J. Firth (AREVA) to Document Control Desk (NRC), Subject "Transmittal of Final Report on the Evaluation of PSC 2-00 Relating to Core Flood Line Break with 2-Minute Operator Action Time," ADAMS ML010950222, April 2, 2001.

AREVA

PROJECT AUTHORIZATION

Steam Generator Committee

PE Contract Number	FANP Job No.	B&WOG Proj. No.	Plant's Tracking No.
101659, W.A.# 4	1011853, Rev. 0	EB-04-08	

Title: Circ Crack In Situ Tests, Part 1

PRICE FOR 2004 WORK	
Initial 2004 Authorization:	$5,992
Previous 2004 Revisions:	$0
This Revision:	$0
'04 Invoices Not To Exceed:	$5,992

Year	Actual or Forecast Amount
2004	$5,992.00
2005	$0.00
2006	$0.00
2007	$0.00

Scheduled Start:	10/01/2004
Scheduled Complete:	12/31/2004

Safety Classification:	Non-Safety Related

SCOPE OF WORK:

Provide services in accordance with Framatome letter FANP-04-3057 dated 09/20/2004.

FANP (contractor) is hereby authorized to perform work under the above Plant Contract dated 01/01/2004 as outlined in the scope of work.

Reviewed by: ______________________ Date: ______
Responsible B&WOG Committee Representative

Approved by: ______________________ Date: ______
B&WOG Steering Committee Representative

Accepted by: ______________________ Date: ______
FANP, Manager, Owners Group Services

☐ Rejected State reason:

AREVA

PROJECT AUTHORIZATION

Steam Generator Committee

FENOC Contract Number	FANP Job No.	B&WOG Proj. No.	Plant's Tracking No.
7115046, TA# FRA-04E-00117	1011853, Rev. 0	EB-04-08	

Title: Circ Crack In Situ Tests, Part 1

PRICE FOR 2004 WORK	
Initial 2004 Authorization:	$5,992
Previous 2004 Revisions:	$0
This Revision:	$0
'04 Invoices Not To Exceed:	$5,992

Year	Actual or Forecast Amount
2004	$5,992.00
2005	$0.00
2006	$0.00
2007	$0.00

Scheduled Start:	10/01/2004
Scheduled Complete:	12/31/2004

Safety Classification:	Non-Safety Related

SCOPE OF WORK:

Provide services in accordance with Framatome letter FANP-04-3057 dated 09/20/2004.

FANP (contractor) is hereby authorized to perform work under the above Plant Contract dated 01/22/2004 as outlined in the scope of work.

Reviewed by: ______________________ Date: ______
Responsible B&WOG Committee Representative

Approved by: ______________________ Date: ______
B&WOG Steering Committee Representative

Accepted by: ______________________ Date: ______
FANP, Manager, Owners Group Services

☐ Rejected State reason:

AREVA

PROJECT AUTHORIZATION

Steam Generator Committee

DEC Contract Number	FANP Job No.	B&WOG Proj. No.	Plant's Tracking No.
DS258	1011853, Rev. 0	EB-04-08	

Title: Circ Crack In Situ Tests, Part 1

PRICE FOR 2004 WORK	
Initial 2004 Authorization:	$5,992
Previous 2004 Revisions:	$0
This Revision:	$0
'04 Invoices Not To Exceed:	$5,992

Year	Actual or Forecast Amount
2004	$5,992.00
2005	$0.00
2006	$0.00
2007	$0.00

Scheduled Start:	10/01/2004
Scheduled Complete:	12/31/2004

Safety Classification:	Non-Safety Related

SCOPE OF WORK:

Provide services in accordance with Framatome letter FANP-04-3057 dated 09/20/2004.

FANP (contractor) is hereby authorized to perform work under the above Plant Contract dated 12/29/2003 as outlined in the scope of work.

Reviewed by: ______________________ Date: _______
Responsible B&WOG Committee Representative

Approved by: ______________________ Date: _______
B&WOG Steering Committee Representative

Accepted by: ______________________ Date: _______
FANP, Manager, Owners Group Services

☐ Rejected State reason: