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FRAMATOME ANP, Inc.

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ATTN: Chief, Planning, Program and Management Support Branch
U.S. Nuclear Regulatory Commission
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Response to Request for Additional Information – BAW-10242(NP), "Zero Power Physics Testing for B&W Reactors" (TAC No. MB9977)

Ref.: 1. Letter, Drew Holland (NRC) to James Mallay (Framatome ANP), "Request for Additional Information – BAW-10242(NP), 'Zero Power Physics Testing for B&W Reactors' (TAC No. MB9977)," August 25, 2003.

In the above referenced letter, the NRC requested additional information to facilitate the completion of its review of the Framatome ANP, Inc. topical report BAW-10242(NP), "Zero Power Physics Testing for B&W Reactors." The response to this request is contained in the attachment to this letter.

The timely completion of the review of this topical report is important because TMI Unit 1 has an opportunity to utilize the results of this topical report in the preparation and planning of the zero power physics test program for startup from the upcoming refueling outage T1R15 (Fall 2003).

Very truly yours,

Gerald S Holm for

James F. Mallay, Director
Regulatory Affairs

Enclosure

cc: D. G. Holland
L. Lois
Project 728

T010

FRAMATOME ANP, Inc.
2101 Horn Rapids Road - Richland, WA 99352
Tel.: 509-375-8100 Fax: 509-375-8402 www.us.framatome-anp.com

Attachment A
Request for Additional Information on Topical Report
BAW-10242(NP), "Zero Power Physics Testing for B&W Reactors"

Regarding the request to eliminate CRG5 from the boron dilution measurement, the NRC staff notes that there are no formal regulatory requirements for the performance of the startup physics tests. In the past, the staff adopted the relevant ANS standards (in this case ANS 19.6.1) or Regulatory Guides (such as RG 1.68) in lieu of regulations.

The staff notes that both versions of ANS-19.6.1 (the current and the proposed revision) clearly state that: "The Standard specifies the minimum acceptable startup reactor physics program (underline added) and acceptable test methods..." to which FANP and the NRC staff have concurred.

The staff also notes that BAW-10242(NP) states, "...present-day-physics codes for predicted CRG worth have demonstrated the ability to calculate individual CRG worth." However, the purpose of the physics tests is not to test the computer codes, rather it is to assure that human or other types of errors did not distort the computer predictions.

Your submittal makes the additional argument that CRG5 is rarely used as a CRG. This essentially delegates CRG5 to the shutdown group of rod clusters. However, the distribution of the CRG5 rods into the core is clearly the same as 6 and 7, i.e., has the characteristics of the CRG.

The staff understands that the reason for the request is to cut down on the time required to perform the CRG boron dilution measurement.

In view of the above, please respond to the following questions.

Question 1: *What is the basis for requesting the change?*

Response 1: Framatome ANP is requesting the change based on the collective study by the B&W-designed plant owners and our staff regarding the appropriate balance between collecting sufficient data during post-refueling zero power physics testing to determine if the core is operating as designed and collecting this data efficiently. Based on several factors (contained in BAW-10242), we have concluded that the measurement of CRG5 by boron dilution provides little added information to the overall purpose of the test program versus the time spent gathering the measured data.

The measurement of rod worth has long been viewed as an important check on what the computer code results are for predicted rod worth, since predicted rod worth is an important component of shutdown margin.

The NRC makes the following statement in the introductory remarks to the questions on BAW-10242(NP):

"However, the purpose of the physics tests is not to test the computer codes rather it is to assure that human or other types of errors did not distort the computer predictions."

The first paragraph of the ANSI-19.6.1 Standard states:

"In conjunction with each refueling shutdown or other significant reactor core alteration, nuclear design calculations are performed to ensure that the reactor physics characteristics of the new core will be consistent with the safety limits. Prior to return to normal operation, successful execution of a physics test program is required to determine if the operating characteristics of the core are consistent with the design predictions and to ensure that the core can be **operated as designed**." (Emphasis added.)

Since reload cores are designed using computer codes, the purpose of physics testing is larger than looking for as-loaded core errors. The identification of core loading errors could be accomplished exclusively with power escalation testing (since power escalation testing, particularly core power distribution verification, is the best method of detecting these errors).

The Framatome ANP recommendations for post-refueling power escalation testing for B&W-designed reactors take advantage of the fixed incore detector system and associated core monitoring software that exist at each of these plants. An outline of the typical B&W-plant post-refueling power escalation test sequence is as follows:

- 10-15% Full Power (FP) – Incore detector checkout, preliminary core power distribution comparisons, begin core symmetry evaluations
- 15-40% FP – Continued power distribution comparisons, core symmetry evaluations
- 40-80% FP – Official core power distribution test
- 80-100% FP – Continued power distribution monitoring
- 100% FP – Official, full power core power distribution test

The core power distribution testing performed at B&W-designed plants during the post-refueling startup sequence is very thorough, going far beyond the minimum requirements set forth in ANSI-19.6.1. Some examples of additional criteria and/or conditions (beyond those imposed by ANSI-19.6.1) imposed by the power escalation testing for B&W-designed plants are:

- Core symmetry requirements revaluated at 10-15% FP
- Preliminary core power distribution evaluations begin at 10-15% FP
- Absolute values of quadrant power tilts are compared to the full power tilt limit
- Measured linear heat rate values are compared to the appropriate LOCA initial-condition based limits
- 95/95 tolerance-based acceptance limits for allowed peaking deviation are applied for EACH fresh fuel location for official core power distribution testing
- Segment peaking factors are examined in addition to radial (assembly) peaking factors

The final, conclusive evidence on determining if a core loading error based on human error or other mechanical problem is present will always be provided by the core power distribution results.

Therefore, a very important component for the request to measure less rod worth by dilution for B&W-designed reactors is that the results obtained from the very thorough power distribution testing that is performed at these units are more reliable, more valid, and more conclusive in revealing as-loaded core anomalies.

Another point not specifically mentioned in the topical report is that one example of a core anomaly that has occurred in the past involving control rods is having an "uncoupled" control rod assembly (CRA). The likelihood of this occurring again at a B&W-designed reactor is extremely remote. Procedural changes were put in place following the last episode of a B&W-plant starting up with an uncoupled rod to prevent the occurrence. Additionally, reviewing the rod drop time test results are a final check to assure that all the rods are coupled. Reference is made to "unlatched" rods in BAW-10242, and it is more correct to refer to this situation as "uncoupled" rather than "unlatched." A reference is also made in BAW-10242 to a situation where an uncoupled rod was not detected by measuring CRG5 worth. One of the episodes of starting up with an uncoupled CRA was with an uncoupled CRA in CRG5. Therefore, to repeat the point emphasized in BAW-10242, the zero power physics testing program did not reveal an uncoupled rod in CRG5 – even measuring CRG5 worth. The fact that the CRA was uncoupled was not revealed until the power escalation sequence.

The primary purpose of the rod worth test is to validate the assumptions on shutdown margin in the reload analysis. Therefore, the basis of the request for measuring CRGs 6 and 7 rather than CRGs 5, 6, and 7 is that this validation can be accomplished with just as much reliability.

Finally, ANSI-19.6.1 allows exceptions to be taken. Section 6.1.5 "Alternate Test Methods" states that new methods and/or new criteria can be considered under certain conditions (consideration of the overall test program, benchmarking, etc.). Framatome ANP attempted to accomplish the relaxation of the 3000 pcm/all control banks proviso within the workings of this committee. Since the ANSI Standard is for all PWRs, the committee decided retain the 3000 pcm/all control banks requirement with the understanding that an exception can be taken.

Questions 2: *What is the data base of the incidents where CRG5 was used as a CRG?*

Response 2: The topical report contains the following: "The ANS 19.6.1 Standard distinguishes between 'control rod groups' and 'safety groups' based on normal practice. While CRG5 is still considered a control rod group, CRG5 is very rarely inserted during normal power operations, such that it is essentially a safety group." Normally, in MODES 1 and 2, B&W plants consist of the three regulating control rod groups (CRGs 5-7) operating in overlap, and the safety groups (CRGs 1-4) are fully withdrawn. The overlap for the regulating CRGs is typically at 25% withdrawn (one unit uses 20% withdrawn for defining group overlap), such that once CRG5 reaches 75% withdrawn, CRG6 begins to lift. When CRG5 is at 100% withdrawn, CRG6 is at 25% withdrawn.

Therefore, the question becomes how often is CRG6 more deeply inserted than 25% withdrawn (because with the control rods in overlap, with CRG6 less than 25% withdrawn, CRG5 is only slightly inserted)?

Current cycle rod insertion limits in the Core Operating Limit Reports restrict plant operation with CRG6 less than 25% withdrawn (a "Rod Index" of 125% withdrawn) below ~40% FP for all times in core life. The percentage of time spent below this power level is very low – typically much less than 0.1% of core life.

A different way to look at this question is where do B&W-designed plants target their estimated critical position (for a "normal" mid-cycle startup)? All B&W-designed plants have a target ECP on CRG6 or higher (greater than 125% withdrawn rod index) and at least two units target criticality on CRG7 (a rod index of greater than 225% withdrawn).

So, in essence, the reactor was over-designed in that it does not need as many regulating rod groups as exist. Therefore, CRG5 simply operates fully withdrawn like the safety groups.

Question 3: *Could you propose an alternate (faster) method to measure CRG5 in place of Boron dilution?*

Response 3: There is not an alternate method to measure the worth of CRG5 in place of the boron dilution approach that would result in a similar time reduction.

When Framatome ANP (then B&W) submitted the Rod Exchange Topical Report (BAW-10175 in 1989), applicability was extended from just the Catawba and McGuire units to include all PWRs. Applying this technique to B&W-designed plants was considered and quickly dismissed on the basis of time. If this technique were to be employed, all control groups would be measured. The dilution of the Reference Bank would be approximately half of the ~3000 pcm measured by CRGs 5-7. However, the swapping of the other six banks would take at least that much time, giving no clear advantage to using that technique.

Framatome ANP (and formerly B&W) has always provided Ag-In-Cd control rods for the B&W-designed plants, and there has never been a wear or loss of absorber material concern that would require the measurement of every bank.

Question 4: *How did you choose the cycles shown in Table 1? What would be the statistics if all available cycle data were used?*

Response 4: The approach was to go at least three cycles back for each unit and to use startups where the same physics code was used as the "official" predictions. Framatome ANP acknowledges that the database for ANO-1 looks "stands out" in that only three cycles of data appear (versus at least four for the other units).

The data for Table 2, Individual Group Worth Comparisons, for ANO-1 Cycle 14 is as follows:

ANO-1 Cycle 14 Control Rod Group Worths at HZP

Control Rod Group	Predicted (pcm)	Measured (pcm)	% Deviation
CRG5	1151	1136	1.30%
CRG6	884	879	0.57%
CRG7	780	783	-0.38%
Sum (5+6+7)	2815	2798	0.60%

Using the additional rod worth data that is available would have little impact on the statistics presented in BAW-10242.

Question 5: *Regarding Section IIIB (4th paragraph) verify that you refer to Table 5 (and not Table 1) and explain how the entries shown in Table 5 were chosen. How would the average and standard deviation change if all of the cycles were represented?*

Response 5: This was a typographical error. The reference should indeed be to Table 5.

The data chosen in Section IIIB were selected based on available data. Any startup for which critical, equilibrium conditions were established with a deeper CRG7 position than "standard" (data where circumstances allowed) was used in Table 5. No such data were selectively excluded.

Question 6: *Respond to the same question for the remaining Tables, i.e. how were the entries shown chosen and are the average and mean values supportive of your argument?*

Response 6: For the differential boron worth (DBW) data in Table 6, insufficient measured boron concentration data existed for many startups. Again, all available data was used.