WCAP-14851-A

Safety Evaluation Supporting The Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement

Original Version: May, 1993
Approved Version: March, 1997

R. J. Fetterman
W. H. Slagle

Approved: S Ray
S. Ray, Manager
Fuel Licensing

Westinghouse Electric Corporation
Commercial Nuclear Fuel Division
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SECTION A

Westinghouse
Electric Corporation

Energy Systems

Nuclear Services Division

Box 355
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NSD-NRC-97-5027
Ref: See attached sheet

March 18, 1997

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

Attention: Mr. J. E. Lyons, Acting Chief
Reactor Systems Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

Dear Mr. Lyons:

Subject: Clarification of Individual Control Bank Worth Benchmark Criteria in WCAP-13749 "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement"

Westinghouse is in the process of publishing the accepted version of WCAP-13749 (Reference 1) as requested by the NRC in Reference 2. The original WCAP was submitted to the NRC for review (Reference 3) in June, 1993. The NRC then requested additional information (Reference 4) in August, 1994, and Westinghouse responded (Reference 5) in January, 1995.

As a part of the methodology documented in Reference 2, a set of core performance benchmark criteria must be met. These benchmark criteria are outlined in Tables 3-2 and D-1 of Reference 2, and are taken from the ANSI/ANS-19.6.1 standard provided in Reference 6.

After further review of the information provided in Reference 2, it was determined that there is a minor inconsistency between the benchmark criteria of Reference 2 and the ANSI standards of Reference 6. Specifically, in Reference 2, the Individual Control Bank Worth benchmark criteria is listed as $\pm 15\%$. However, Reference 6 lists the Individual Control Bank Worth benchmark criteria as $\pm 15\%$ or $\pm 0.1\% \rho$ (100 pcm). It was intended that the core performance benchmark criteria documented in Reference 2 be complete and consistent with the ANSI standard of Reference 6.

Therefore, to remain consistent with the complete ANSI standard, Westinghouse will require the Individual Control Bank Worth benchmark criteria of $\pm 15\%$ or $\pm 0.1\% \rho$ (100 pcm) be used for application of the conditional exemption from performing the most negative moderator temperature coefficient measurement.

As discussed with Mr. Richings, this letter will be included in the proprietary and non-proprietary approved versions of Reference 2, (i.e, WCAP-13749-P-A and WCAP-14851-A) as a way of documenting the complete benchmark criteria to be used with this methodology.

If you should have any questions concerning the information provided above, please contact Mr. Sumit Ray, Manager, Core Engineering. He may be reached at (412) 374-2101.

Very truly yours,

N. J. Liparulo, Manager
Equipment Design and Regulatory Engineering

References

1. "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," WCAP-13749, May 1993 [Proprietary]

2. Letter from R. C. Jones (NRC) to N. J. Liparulo (Westinghouse), "Acceptance for Referencing of Licensing Topical Report WCAP-13749-P, 'Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL [End-of-Life] Moderator Temperature Coefficient Measurement,'" October 9, 1996.

3. Letter from N. J. Liparulo (Westinghouse) to R. C. Jones (NRC), WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," ET-NRC-93-3894, June 1, 1993.

4. Letter from R. C. Jones (NRC) to N. J. Liparulo (Westinghouse), "Request for Additional Information for Westinghouse Topical Report WCAP-13749," (TAC No. M86764), August 4, 1994.

5. Letter from N. J. Liparulo (Westinghouse) to R. C. Jones (NRC), "Response to Request for Additional Information on WCAP-13749, Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," [Proprietary], NTD-NRC-95-4384, January 16, 1995.

6. "Reload Startup Physics Tests for Pressurized Water Reactors," ANSI/ANS-19.6.1-1985, December 1985.

SECTION B

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

October 9, 1996

Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: ACCEPTANCE FOR REFERENCING OF LICENSING TOPICAL REPORT WCAP-13749-P, "SAFETY EVALUATION SUPPORTING THE CONDITIONAL EXEMPTION OF THE MOST NEGATIVE EOL [END-OF-LIFE] MODERATOR TEMPERATURE COEFFICIENT MEASUREMENT"

Dear Mr. Liparulo:

The staff has reviewed WCAP-13749-P, the topical report submitted by Westinghouse Electric Corporation in its letter of June 1, 1993. The report is acceptable for referencing in license applications to the extent specified and under the limitations stated in the enclosed Brookhaven technical evaluation (TER) report and the U.S. Nuclear Regulatory Commission (NRC) staff's safety evaluation report (SER). The SER and TER give the basis for the staff's acceptance of the report. The staff will develop a line item change for the Westinghouse standard technical specifications (NUREG-1431) incorporating, for use when applicable, the methodology indicated in this topical report.

The staff will not repeat its review of the matters described in the topical report and found acceptable when it appears as a reference in license applications, except to ensure that the material presented applies to the specific plant involved. NRC acceptance applies only to the matters described in the topical report. In accordance with procedures established in NUREG-0390, the NRC requests that Westinghouse Electric Corporation publish accepted versions of WCAP-13749-P, proprietary and nonproprietary, within 3 months of receipt of this letter. The accepted versions shall incorporate this letter and the enclosed SER and TER between the title page and the abstract, and an -A (designating accepted) should follow the report identification symbol. Westinghouse shall also incorporate the report "Responses to Request for Additional Information on WCAP-13749-P, 'Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement,'" January 16, 1995.

If NRC's criteria or regulations change so that its conclusion that the report is acceptable is invalidated, Westinghouse Electric Corporation and any applicant referencing the topical report will be expected to revise and resubmit the respective documentation, or submit justification for the continued applicability of the topical report without revision of the respective documentation.

Sincerely,

Timothy E. Collins / for

Robert C. Jones, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis
Office of Nuclear Reactor Regulation

Enclosure:
WCAP-13749-P Evaluation

SECTION C

SAFETY EVALUATION REPORT FOR WCAP-13749-P
"SAFETY EVALUATION SUPPORTING THE CONDITIONAL EXEMPTION OF THE MOST NEGATIVE EOL [END-OF-LIFE] MODERATOR TEMPERATURE COEFFICIENT MEASUREMENT"
(TAC NO. M86764)

1.0 INTRODUCTION

In a letter dated June 1, 1993 (Ref. 1), Westinghouse submitted to the U.S. Nuclear Regulatory Commission (NRC) topical report WCAP-13749-P, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement." This report replaced a previous similar report, WCAP-13610-P, which was withdrawn by Westinghouse after a preliminary NRC review that found the proprietary classification of a technical specification (TS) to be unacceptable. In a letter dated January 16, 1995 (Ref. 2), Westinghouse also submitted a supplement to the report in response to NRC's request for additional information (Ref. 3).

In these reports, Westinghouse proposed a generic change to the Westinghouse TS requirement for surveillance of the end of life EOL moderator temperature coefficient (MTC). Currently, most Westinghouse TS (including the new TS of NUREG 1431) require that a measurement be made near EOL (within 7 effective full-power days (EFPDs) after an equilibrium boron concentration of 300 ppm is reached) and compared to the TS surveillance value listed in the TS for the full-power, all control rods withdrawn condition. If the measurement does not fall within the TS surveillance limit, the MTC must be remeasured every 14 EFPDs for the remainder of the cycle to ensure the value does not exceed the TS limiting condition for operation (LCO) value the remainder of the cycle. Each measurement requires several hours or more at less than full power operation (as a buffer to measurement transients) and additional manpower, and presents a perturbation to normal operation.

As a result of the incorporation of a near end-of-cycle MTC measurement into the TS for pressurized water reactors about 1980, a significant amount of information has been gathered on how well the EOL MTC was calculated using the vendor methodologies. Westinghouse has proposed, on the basis of extensive relevant experience in calculations, measurements, and comparisons, that if a specified revised prediction of the MTC and limits for several core parameters measured during the cycle are within specified bounds, the EOL MTC measurement need not be made.

It should be noted that, for Westinghouse, the negative MTC of the TS (and TS bases) and the MTC discussed in the topical report, are used only in the Westinghouse event analyses in which a constant (as a function of moderator temperature), bounding negative MTC value is used. These events are listed in the report in Table 4-1. This list does not include the steam line break events, for which a variable value (as a function of moderator density) is used. That aspect of the negative MTC is not discussed in the topical report or this review. The coefficient for the steam line break events is discussed in the Westinghouse topical report WCAP-9226, "Reactor Core Response To Excessive Secondary Steam Releases," which has been reviewed and approved by the staff, and which describes the methodology used for those analyses. Westinghouse has always kept the two groups of analyses separate.

2.0 EVALUATION

The NRC contractor, Brookhaven National Laboratory (BNL), helped the staff review this topical report and has written a technical evaluation report (TER) that is included in this report as Attachment 1. The TER contains a discussion and evaluation of the proposed change and Westinghouse justifications. These areas will not be discussed in detail here. The staff has reviewed the TER and adopts its conclusions. The remainder of this section primarily addresses the requested changes to the TS and a new report to be submitted each cycle with information on the EOL MTC.

It should also be noted that Westinghouse has added significant information to the topical report in its response (Ref. 2) to the NRC request for additional information (Ref. 3). The response to question 1, in particular, contains additions to the data-base and a conservative change to the predictive correction factor (discussed in the TER). New tables are presented to replace some of the information in the tables of the report and Appendix D. Users of the methodology should use the revised algorithm and work sheet given in the response to questions about calculation of the revised prediction.

The data from comparison of measurements (M) and predictions (P) of the MTC indicate that there is a conservative bias of the mean of M-P. The formulation of the revised prediction (discussed in the TER) also provides another conservative factor in the predictive correction term in the revised formulation. These conservative factors are in addition to the use of control rod insertion in calculating the negative MTC used in safety analyses (discussed in Westinghouse MTC TS bases and in the TER) that serves as a starting point for determining the TS EOL MTC limit and surveillance value.

The staff has concluded that the proposed methodology for deciding when the EOL MTC surveillance may be bypassed is acceptable.

3.0 TECHNICAL SPECIFICATIONS

The topical report presents in four appendices, A through D, prescriptions to be followed in revising existing MTC TS and core operating limits reports (COLRs) to provide for possible cycle-specific elimination of the EOL surveillance measurements. Appendices A and C give examples of changes required for a TS associated (A) with and (C) without a COLR. Appendix B presents changes and additions to the COLR and to TS 6.9, where requirements for COLRs are stated.

The four appendices present the newly required most negative moderator temperature coefficient limit report (MTC limit report), which is to be submitted each cycle (the same as the COLR). The requirement for this report is to be inserted in TS 6.9 (also the same as for the COLR). Appendix D gives an example of the report, which includes limitations, procedures, benchmark criteria, and the algorithm for determining the revised predicted surveillance MTC limit. Note that in Appendix D the algorithm for determining the revised prediction has been revised in the response to staff questions (referred to above). The revised version should be used.

In incorporating the possibility of bypassing the surveillance measurement, no changes are to be made to the existing TS, either in the LCO statement, the action items, or the surveillance requirements. The only change is the addition of a footnote to the surveillance TS indicating the surveillance may be suspended if benchmark criteria are met and the revised MTC prediction meets the TS EOL surveillance limit. Also stated is that the information needed to make that judgment is in the appendices of WCAP-13749 (the words "as revised in response to staff questions" should be added) and in the TS or the COLR and the MTC limit report. (WCAP-13749 was submitted in Reference 1. The revision is in Reference 2, which is in response to Reference 3.)

Given the acceptability of the methodology for deciding the possibility of eliminating the EOL MTC surveillance requirement on a cycle basis, these TS changes provide an acceptable process for specifying and controlling the necessary steps.

4.0 CONCLUSIONS

As stated in the conclusions of the accompanying TER, the analysis for the proposed TS change is acceptable, provided (1) only PHOENIX/ANC calculation methods are used for the individual plant analyses relevant to determinations for the EOL MTC plant methodology, and (2) the predictive correction is reexamined if changes in core fuel designs or continued MTC calculation/measurement data show significant effect on the predictive correction.

On the basis of its and BNL's review, the staff concludes that the methodology described in WCAP-13749 (as modified as a result of the changes described in the response to staff questions (Ref. 2)), is suitably conservative and acceptable as a reference for proposed changes to relevant technical specifications.

5.0 REFERENCES

1. Letter from N. J. Liparulo, Westinghouse, to USNRC, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," WCAP-13749-P, June 1, 1993.

2. Letter from N. J. Liparulo, Westinghouse, to USNRC, attention R. C. Jones, "Responses to Request for Additional Information on WCAP-13749-P, 'Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement'," January 16, 1995.

3. Letter from R. C. Jones, USNRC, to N. J. Liparulo, Westinghouse, "Request for Additional Information for Westinghouse Topical Report, WCAP-13749," August 5, 1994.

TECHNICAL EVALUATION REPORT

Topical Report Title:	Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement.
Topical Report Number:	WCAP-13749
Report Issue Date:	May 1993
Originating Organization:	Westinghouse Electric Corporation, Commercial Nuclear Fuel Division.

1.0 INTRODUCTION

In Reference-1, dated June 1, 1993, the Westinghouse Electric Corporation (W) has submitted the Topical Report WCAP-13749 for NRC review and approval. This report provides the safety evaluation supporting the conditional exemption from performing the standard End-Of-Life (EOL) most negative moderator temperature coefficient measurement. The topical report and safety evaluation are intended for application to W plants presently required by the Technical Specification surveillance requirements to perform an EOL Moderator Temperature Coefficient (MTC) measurement. The topical report specifies the criteria and conditions that must be satisfied for the suspension of the temperature coefficient measurement.

The WCAP-13749 safety evaluation identifies the conservatism in the margin between the moderator density coefficient used in the FSAR safety analyses, and the Technical Specification most negative MTC Limiting Condition of Operation (LCO) and Surveillance Requirement (SR). The two methods currently used to relate the safety analysis most positive moderator density coefficient to the LCO most negative moderator temperature coefficient are described and also shown to be conservative. An MTC calculational algorithm is provided which allows the prediction of the EOL moderator temperature coefficient in lieu of an MTC measurement.

The purpose of this review was to evaluate the acceptability of the WCAP-13749 safety analysis for the suspension of the EOL MTC measurement. This involved the evaluation of both the MTC prediction algorithm and the specific conditions and criteria for suspending the MTC measurement. The WCAP-13749 methodology and safety evaluation are summarized in Section-2, and the evaluation of the important technical issues raised during this review is presented in Section-3. The technical position is given in Section-4.

2.0 SUMMARY OF THE TOPICAL REPORT

The Chapter-15 FSAR analyses (other than steamline break which is not addressed in this report) which become more severe with increasing moderator feedback assume a constant bounding Moderator Density Coefficient (MDC). This coefficient is selected to be more positive than the cycle-specific reload core MDC under the worst-case initial and transient conditions (Note that a positive MDC corresponds to a negative MTC). The design basis safety analyses are sensitive to the value of the core reactivity feedback assumed in the accident analyses. Since the reload core and fuel design can have a substantial effect on the reactivity feedback, as described in Reference-2, these coefficients are determined for each cycle to confirm the conservatism of the bounding values assumed in the accident analyses.

Since the moderator temperature coefficient (rather than the density coefficient) is measured, the technical specification LCO is based on the MTC. The Technical Specification most negative MTC measurement is made near end-of-life, where the MTC is most negative, and insures that the MDC assumed in the FSAR is bounding.

The most positive MDC used in the FSAR analyses is based on the Hot-Full-Power (HFP) EOL value with no soluble boron and rods inserted. There are two methods currently used to relate this rods inserted MDC to the near-EOL moderator temperature coefficient measurement. These are: (1) the all rods inserted (ARI)-to-all rods out (ARO) MTC conversion and (2) the most negative feasible MTC conversion. In the ARO-to-ARI conversion, the difference between the ARI and ARO HFP moderator density coefficient is calculated and used to determine the ARO MDC limit. Standard thermodynamic properties are then used to convert the MDC limit to an equivalent MTC limit. In the topical report, W notes that the ARI-to-ARO conversion is conservative because of the differences between the HFP ARI statepoint and the Technical Specification requirements for allowable operation.

In the most negative feasible MTC conversion, the FSAR MDC is first converted to an equivalent MTC and then related to the MTC for the statepoint having the most negative MTC allowed by the Technical Specifications. In this conversion, the operating parameters that affect the MTC are simultaneously taken to be at their most limiting values. Since these parameters are generally independent and sometimes mutually exclusive, the most negative feasible conversion is also considered to be conservative. W also indicates that there is generally additional conservatism between the reload core design most negative MTC and the MTC (equivalent) value used in the Chapter-15 FSAR accident analyses.

The WCAP-13749 Topical Report provides specific criteria that, if satisfied, allow the suspension of the most negative EOL measurement technical specification requirement. The suspension criteria include a most negative limit on the predicted MTC, together with an accuracy requirement on the core performance predictions. Westinghouse has evaluated the EOL MTC effects of: (1) changes in the Axial Flux Difference (AFD), (2) global core reactivity and (3) prediction accuracy. The MTC increases with decreasing AFD due to the increased feedback associated with the higher fuel burnup in the bottom of the core, and because of the increased spatial weighting of the change in the moderator temperature. The most negative EOL MTC measurement exemption is based on the conditions that: (1) the MTC prediction is less than a precalculated limit, and (2) the specified core performance prediction accuracy limits are satisfied.

The revisions to the Technical Specifications, required by the proposed EOL MTC measurement exemption, are included for both the cases with and without the Core Operating Limits Report (COLR). An EOL MTC prediction worksheet is also included in the topical report.

3.0 SUMMARY OF THE TECHNICAL EVALUATION

The Westinghouse Topical Report WCAP-13749 provides the safety evaluation for the conditional exemption of the most negative EOL moderator temperature coefficient measurement. The review of WCAP-13749 focused on the adequacy of the MTC prediction algorithm, and the specific conditions and criteria for suspending the MTC measurement. Several important technical issues were raised during the initial review which required additional information and clarification from Westinghouse. This information was requested in Reference-3 and was provided in the W response included in Reference-4. This evaluation is based on the material presented in the topical report and in Reference-4. The evaluation of the major issues raised during this review are summarized in the following.

The Westinghouse methodology for the EOL MTC measurement exemption is based, in part, on the accuracy of the PHOENIX/ANC calculational methods as determined by comparisons to benchmark calculations and measurements. These methods and their associated benchmarking are described in References 5-6 and summarized in the topical report. The application of the EOL MTC measurement exemption, with calculational methods other than PHOENIX/ANC, will require additional methods benchmarking to insure that the uncertainty limits assumed in WCAP-13749 are satisfied.

The MTC exemption methodology requires that specific benchmark accuracy criteria be satisfied to demonstrate the applicability of the PHOENIX/ANC core models and associated MTC calculational uncertainties. W has indicated in Response-8 (Reference-4) that these criteria will be verified during the startup physics testing and during the cycle. The power distribution calculation will be confirmed during the incore flux surveillance, which is typically performed monthly. The core reactivity calculation will be confirmed using the daily Hot-Full-Power boron concentration measurements.

In the EOL MTC measurement exemption methodology, the plant measurement is replaced by a detailed design calculation of the core moderator temperature coefficient. Westinghouse has provided benchmarking comparisons to support the MTC calculational uncertainty values assumed in the exemption methodology. In Response-4 (Reference-4), W has indicated that the calculation-to-measurement comparison statistics do not have any significant dependence on the core and fuel design parameters or on cycle length. The data base includes a large sample of core types (2, 3 and 4 loop plants), moderator temperatures, enrichments and burnable poison designs.

The BOL MTC measurement is made at Hot-Zero-Power (HZP) conditions and is an accurate measurement characterized by relatively small uncertainties. The EOL MTC measurement is made at Hot-Full-Power conditions, and the calculation-to-measurement differences are typically larger (than for the BOL zero power case) due to the presence of xenon, increased doppler feedback and fuel burnup. In the proposed WCAP-13749 methodology, the EOL MTC measurement (made to insure that the MTC is less negative than the value assumed in the safety analysis) is replaced by a design calculation. In order to take explicit account of the uncertainty in the MTC calculation, W applies a predictive correction to the calculated EOL HFP moderator temperature coefficient. A predictive correction has been determined based on: (1) an extrapolation of the BOL HZP MTC calculational uncertainty to EOL HFP conditions, and (2) an extensive data base of comparisons of measured and calculated EOL HFP moderator temperature coefficients (Response-1, Reference-4). It should be noted that the initial predictive correction given in the Topical Report was increased substantially in the W Reference-4 response to the RAI. As additional justification for this correction, in Response-1 (Reference-4), Westinghouse has indicated that there is a substantial amount of conservative margin between the most negative safety analysis MTC and the corresponding design MTC (calculated at the same limiting conditions) to accommodate the MTC calculational uncertainty. This predictive correction is included in the WCAP-13749 algorithm used to determine the revised near-EOL 300 ppm MTC. If future changes in core/fuel designs or the MTC calculation-to-measurement data base have a significant effect on the determination of the predictive correction, the MTC predictive correction should be reevaluated.

4.0 TECHNICAL POSITION

The Topical Report WCAP-13749 and supporting documentation provided in Reference-4 have been reviewed in detail. Based on this review, it is concluded that the safety evaluation supporting the conditional exemption of the most negative EOL moderator temperature coefficient measurement is acceptable, subject to the conditions stated in Section-3 of this evaluation and summarized in the following.

1) Application with Methods other than PHOENIX/ANC

The application of the WCAP-13749 EOL MTC measurement exemption with calculational methods other than PHOENIX/ANC will require additional methods benchmarking to insure that the uncertainty limits assumed in WCAP-13749 are satisfied (Section-3).

2) Changes in Core/Fuel Designs and the Measurement Data Base

The predictive correction should be reevaluated if changes in core/fuel designs or the MTC calculation-to-measurement data base have a significant effect on the MTC predictive correction (Section-3).

REFERENCES

1. "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," WCAP-13749, Letter, N.J. Liparulo (W) to USNRC, Dated June 1, 1993.

2. Davidson, S.L., Kramer, W.R., "Westinghouse Reload Safety Evaluation Methodology," WCAP-9272-P-A (Westinghouse Proprietary), July 1985.

3. "Request for Additional Information for Westinghouse Topical Report, WCAP-13749," Letter, R.C. Jones (USNRC) to N.J. Liparulo, Dated August 5, 1994.

4. "Responses to Request for Additional Information on WCAP-13749 'Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement,'" Letter, N.J. Liparulo (W) to USNRC, Attention R.C. Jones, Dated January 16, 1995.

5. Nguyen, T.Q., et al., "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," WCAP-11596-P-A (Westinghouse Proprietary), June 1988.

6. Liu, Y.S., "ANC: A Westinghouse Advanced Nodal Computer Code," WCAP-10965-P-A (Westinghouse Proprietary), December 1985.

SECTION D

Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

June 1, 199?
ET-NRC-93-3894

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

Attention: R. C. Jones, Reactor Systems Branch Chief, Division of Engineering and System Technology

Subject: "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement," WCAP-13749, May 1993 [Proprietary]

Reference: (1) Letter from N. Liparulo (Westinghouse) to R. C. Jones (NRC), ET-NRC-93-3792, February 1, 1993.
(2) Letter from R. C. Jones (NRC) to N. J. Liparulo (Westinghouse) February 25, 1993.

Dear Mr. Jones:

Reference (1) contained the submittal of WCAP-13610, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement" [Proprietary]. Reference (2) requested that the Westinghouse Proprietary Information in the WCAP-13610 proposed Technical Specifications be removed. Due to the nature of this change, it is recommended by Westinghouse to withdraw WCAP-13610 from your Document Control, and replace it with a new topical report, WCAP-13749; but maintain the same topical title.

Enclosed are fifteen (15) copies of WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement [Proprietary] for your review and approval. At our April 16th Topical Review Meeting in Rockville, Westinghouse noted that the SER need date for this topical was driven by the customer (topical to be placed on both the Sequoyah and D. C. Cook dockets in the 3rd quarter of 1993) and was assigned a medium review priority.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10CFR9.5(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the express prior written approval of Westinghouse.

Correspondence with respect to any Application for Withholding should reference AW-93-479 and should be addressed to N. J. Liparulo, Manager of Regulatory and Legislative Affairs, Westinghouse Electric Corporation, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities

cc: L. E. Phillips - NRC (MS 8E23)

Westinghouse Electric Corporation

Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

June 1, 1993
AW-93-479

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

Attention: Mr. R. C. Jones, Reactor Systems Branch Chief, Division of Engineering and System Technology

Reference: Letter from N. J. Liparulo (Westinghouse) to R. C. Jones (NRC), ET-NRC-93-3894, dated June 1, 1993

Subject: "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient," WCAP-13749 May 1993 [Proprietary]

Dear Mr. Jones:

The above referenced letter contains information proprietary to the Westinghouse Electric Corporation.

The material will not be employed as a part of a license application or other action identified in 10CFR2.790(a) at this time. It will be separately submitted with an Application for Withholding accompanied by an Affidavit meeting the requirements of 10CFR2.790(b) prior to such use.

Accordingly, we request that the material be treated as proprietary information within the provisions of 10CFR9.5(4), "Freedom of Information Act Regulations." If there is a need to make public disclosure of the material prior to a separate Westinghouse submittal for docket in accordance with the provisions of 10CFR2.790(a), please notify Westinghouse prior to making a disclosure determination.

Correspondence with respect to the proprietary aspects of this submittal should reference AW-93-479 and should be addressed to the undersigned.

Very truly yours,

H le Sepp/for

Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities

cc: K. Bohrer/NRC 12H5

SECTION E

WCAP-13749

Safety Evaluation Supporting The Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement

May, 1993

R. J. Fetterman

Approved: A Kacadei   DJ Love

A. L. Casadei, Manager
NMD Core Engineering

D. S. Love, Manager
NATD Transient Analysis I

Westinghouse Electric Corporation
Nuclear Manufacturing Divisions
P. O. Box 355
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ABSTRACT

This report proposes modifying the EOL Moderator Temperature Coefficient (MTC) surveillance by placing a set of conditions on core operations which, if met, would allow for the exemption of Surveillance Requirement (SR) measurement. The conditional exemption from the measurement will be determined on a cycle-specific basis considering the amount of margin predicted to the SR MTC limit and the performance of other core parameters such as beginning of cycle MTC measurements and the critical boron concentration as a function of cycle length. The conditional exemption from the measurement is sought to improve plant availabilityand minimize disruptions to normal plant operation. Plant safety criteria will not be compromised by conditional exemption of this one measurement.

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ACKNOWLEDGEMENTS

The author of this report gratefully acknowledges the following individuals for their contributions to the completion of this report: F. B. Baskerville, D. J. Hill, F. J. Silva and C. R. Tuley.

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1.0 INTRODUCTION

1.1 BACKGROUND

For FSAR accident analyses, the transient response of the plant is dependent on reactivty feedback effects, in particular, the moderator density coefficient (MDC) and the Doppler power coefficient. Because of the sensitivity of accident analysis results to the MDC value assumed, it is important that the actual core MDC remain within the bounds of the limiting values assumed in the FSAR accident analyses. While core neutronics analyses will have confirmed that the MDC is within these bounds, the Technical Specifications also place limits on the moderator temperature coefficient (MTC) that can be obtained during normal operation. MTC measurements are performed at the beginning of cycle prior to initial operation above 5% rated thermal power. Most plants also currently have a requirement to measure the MTC at rated themal power conditions within 7 EFPD after reaching an equilibrium boron concentration of 300 ppm.

1.2 BASIS OF THE END OF LIFE MTC LIMITING CONDITION FOR OPERATION AND SURVEILLANCE REQUIREMENT

In order to ensure a bounding accident analysis, the MDC is assumed to be at its most limiting value for the analysis conditions appropriate to each accident. The most positive MDC limiting value is based on end of life (EOL) core conditions corresponding to maximum fuel burnup and minimum boron concentration assuming 100% rated thermal power. Two different Technical Specification bases relating the accident analysis MDC to the most negative MTC have been previously licensed for Westinghouse plants, and are described in Chapter 2 of this report.

Most accident analyses use a constant MDC designed to bound the MDC at the worst set of initial conditions as well as at the most limiting set of transient conditions. This value of MDC forms the licensing basis for the FSAR accident analysis as well as the bases for the current EOL MTC Technical Specification requirements.

Converting the MDC used in the accident analyses to a corresponding MTC is a simple calculation which accounts for the rate of change of moderator density with temperature at the conditions of interest. In this report, the convention followed is to discuss the moderator feedback in terms of MTC, consistent with the Technical Specification requirements, rather than MDC.

Technical Specifications place both Limiting Condition for Operation (LCO) and Surveillance Requirement (SR) constraints on the MTC, based on the accident analysis assumptions of the MDC. The most positive MTC LCO limit applies to Modes 1 and 2, and requires that the MTC be less positive than the specified limit value. The most negative MTC LCO limit applies to Modes 1, 2 and 3, and requires that the MTC be less negative than the specified limit value for the all rods withdrawn, end of cycle life, rated thermal power condition.

The Technical Specification SR calls for measurement of the MTC at BOL of each cycle prior to initial operation above 5% rated thermal power, in order to demonstrate compliance with the most positive MTC LCO. Similarly, to demonstrate compliance with the most negative MTC LCO, the Technical Specification SR calls for verification of the MTC after the near-EOL 300 ppm equilibrium boron concentration is obtained. Because the HFP MTC value will gradually become more negative with further core depletion and boron concentration reduction, a 300 ppm SR value of MTC should necessarily be less negative than the EOL LCO limit. To account for this effect, the 300 ppm SR value is sufficiently less negative than the EOL LCO limit value, providing assurance that the LCO limit will be met as long as the 300 ppm surveillance criterion is met.

2.0 BASES FOR THE MOST NEGATIVE MTC TECHNICAL SPECIFICATION VALUES

2.1 ACCIDENT ANALYSIS MDC ASSUMPTION

The FSAR accident analyses upon which the Technical Specification most negative MTC LCO is based have assumed bounding values of the MDC in order to ensure a conservative simulation of the plant transient response. For those transients for which analysis results are made more severe by assuming maximum moderator feedback, a constant MDC has been assumed to exist throughout the transient. These transients are discussed in Chapter 4.

When discussing the Technical Specification EOL LCO on moderator feedback, it is better to consider the most negative MTC rather than the most positive MDC since moderator temperature is the measurable quantity. For this reason, the accident analysis assumption of a constant MDC is converted to its equivalent MTC. This conversion depends on the relationship of density change to temperature change at the moderator temperature and pressure consistent with the nornal operating condition of hot full power and full flow. This is the core condition at which the MDC will be at its most positive value under normal operating conditions. The accident analysis equivalent MTC is then converted to the Technical Specification LCO for the most negative MTC by one of the two methods discussed below. While the accident analyses constant MDC is converted to an MTC for the purpose of determining the most negative MTC LCO, the accident analyses do not make an explicit assumption about the MTC.

2.2 CONVERSION OF SAFETY ANALYSIS MDC TO TECHNICAL SPECIFICATION MTC

As stated previously, the FSAR accident analyses bound the potential values of the moderator density coefficient (MDC), ensuring a conservative result for the transient analyzed. The process by which this accident analysis most positive MDC is transformed into the most negative MTC LCO value is described in the Westinghouse Standard Technical Specification (STS) BASES. Two methodologies, the ARI to ARO conversion and the Most Negative Feasible MTC conversion, have been previously licensed. For the ARI to ARO conversion:

"The most negative MTC value equivalent to the most positive Moderator Density Coefficient (MDC), was obtained by incrementally correcting the MDC used in the FSAR analyses to nominal operating conditions. These corrections involved subtracting the incremental change in the MDC associated with a core condition of all rods inserted (most positive MDC) to

an all rods withdrawn condition and, a conversion for the rate of change of moderator density with temperature at RATED THERMAL POWER conditions. This value of the MDC was then transformed into the limiting MTC value of ...."

For the Most Negative Feasible MTC conversion:

"The most negative MTC value equivalent to the most positive Moderator Density Coefficient (MDC), was obtained by incrementally correcting the MDC used in the FSAR analyses to nominal operating conditions. These corrections involved: (1) a conversion of the MDC used in the FSAR safety analyses to its equivalent MTC, based on the rate of change of moderator density with temperature at RATED THERMAL POWER conditions, and (2) subtracting from this value the largest differences in MTC observed between EOL, all rods withdrawn, RATED THERMAL POWER conditions, and those most adverse conditions of moderator temperature and pressure, rod insertion, axial power skewing, and xenon concentration that can occur in normal operation and lead to a significantly more negative EOL MTC at RATED THERMAL POWER. These corrections transformed the MDC value used in the FSAR safety analyses into the limiting MTC value of ...."

In the process of converting the accident analysis MDC into the corresponding MTC for the Technical Specifications, the conversion for the rate of change of moderator density with temperature at rated thermal power conditions involves conventional thermodynamic properties and imposes no undue conservatism on the resulting MTC value. The additional conversion made is to correct the above MDC (MTC) value for the change associated with going from the initial core conditions assumed for a transient to the normal operating conditions of EOL, ARO, HFP and 0 ppm. The details of this additional conversion are discussed below.

2.3 Conservatism of the ARI to ARO MTC Conversion

This conversion is part of the original basis for the most negative MTC limit in the Westinghouse STS. The accident analysis MDC (MTC) assumes a coefficient determined for a condition of EOL HFP 0 ppm with all control and shutdown banks fully inserted. This accident analysis MDC (MTC) is corrected back to the ARO condition, in order to produce a Technical Specification limit which permits direct comparison against measured values. The effect of the full insertion of all control and shutdown banks is to make the MTC significantly more negative than an MTC at the ARO condition, hence the ARI assumption has a substantial impact.

This conversion is unnecessarily restrictive as the HFP ARI assumption is inconsistent with Technical Specification requirements for allowable operation. Shutdown banks are not permitted to be inserted during power operation and control banks must be maintained above their insertion limits. The ARI to ARO conversion then leads to overly conservative limits for the most negative MTC LCO and SR.

2.4 Conservatism of the Most Negative Feasible MTC Conversion

The Most Negative Feasible MTC conversion is the second licensed basis for the most negative MTC limits. This conversion assumes the conditions at which a core will exhibit the most negative MTC value are consistent with operation allowed by the Technical Specifications. As an example, the Most Negative Feasible MTC approach does not require a conversion assumption that all rods be fully inserted at HFP conditions, but does require a conversion assumption that all control banks are inserted the maximum amount that Technical Specifications permit, so as to make the calculated EOL HFP MTC more negative than it would be for an unrodded core.

The Most Negative Feasible MTC approach determines EOL MTC sensitivity to those design and operational parameters that directly impact MTC, and attempts to make this determination in a such a manner that the resulting sensitivity for one parameter is independent of the assumed values of the other parameters. As a result, parameters which are mutually exclusive but permissible according to the Technical Specifications (such as an assumption of full power operation and an assumption of no xenon concentration in the core), and which serve to make MTC more negative, will have their incremental impacts on MTC combined to arrive at a conservative and bounding condition for the most negative feasible MTC. The parameters which are variable under normal operation and which affect MTC are the soluble boron concentration in the coolant, the moderator temperature and pressure, the amount of RCCA insertion, the axial flux (power) shape, and the transient fission product (xenon) concentration. The maximum deviation of each of these parameters from nominal core conditions (HFP, ARO, equilibrium xenon, Tavg on the reference temperature program) is determined from the Technical Specifications and multiplied by the appropriate MTC sensitivity to arrive at the **"delta MTC"** factor associated with each parameter.

It is conservatively assumed that these largely independent parameters are at their extreme conditions simultaneously. Bounding **"delta MTC"** factors are determined for each of the above parameters, and these factors are then added to arrive at an overall bounding **"delta MTC"** factor. This overall **"delta MTC"** factor states how much more negative the MTC can become, relative to the nominal EOL HFP ARO MTC value, for normal operation scenarios permitted by the current Technical Specifications. The conditions of moderator temperature, rod insertion, xenon, etc., which defined the Most Negative Feasible MTC condition become the conversion proposed as a replacement for the ARI to ARO conversion of the current MTC Technical Specification. The conversion for the Most Negative Feasible MTC condition is applied in the same way that the ARI to ARO conversion is applied, in order to arrive at an EOL HFP ARO MTC Technical Specification LCO limit that remains based on the accident analysis MDC assumption.

2.5 Determining SR MTC from LCO MTC

Under the Most Negative Feasible MTC approach, the 300 ppm surveillance value is determined in the manner currently stated in the Westinghouse STS BASES:

"The MTC value ... represents a conservative value (with corrections for burnup and soluble boron) at a core condition of 300 ppm equilibrium boron concentration and is obtained by making these corrections to the limiting MTC value...."

That is, the 300 ppm surveillance value is derived by making a conservative adjustment to the EOL HFP ARO MTC limit value that accounts for the change to MTC with soluble boron and burnup. For the ARI-to-ARO conversion bases for the most negative MTC, it is also conservatively assumed that the difference between the 300 ppm HFP SR MTC and the EOL (0 ppm) HFP LCO MTC is 9 pcm/°F. For the most negative feasible approach, it has been determined that this difference is typically smaller than 9 pcm/°F. This difference is plant-specific and is determined as part of a plant's most negative feasible MTC licensing submittal.

3.0 CONDITIONAL EXEMPTION OF THE MOST NEGATIVE MTC SR MEASUREMENT

3.1 MTC TECHNICAL SPECIFICATION SURVEILLANCE REQUIREMENTS

The current Westinghouse STS have several different Surveillance Requirements (SR) which can be separated into the two major categories of power distribution and core reactivity. The SR measurements serve to demonstrate that the core is operating as predicted by the design models, in turn verifying that the safety analyses assumptions are valid. The power distribution SR include limits on axial power distributions, quadrant power tilts and peaking factors. The core reactivity SR include measurements of reactivity derivatives such as MTCs and acceptance criteria on the global reactivity which is verified by routine measurements of the critical soluble boron concentration. Additional measurements of reactivity parameters and power distributions are performed prior to the startup of each cycle to verify the accuracy of the design models.

As part of the Westinghouse reload design process described in Reference 1, the design models are used to verify the core physics inputs assumed in the reload safety evaluations and analyses, including the most positive MDC assumed in the EOL limiting transients, as well as the most positive and most negative MTC limits in the Technical Specifications.

Currently, the Westinghouse STS requires measurements of MTCs at BOL to verify the most positive MTC limit and near EOL to verify the most negative MTC limit. At BOL, the measurement of the isothermal temperature coefficient (ITC) is relatively simple to perform since it is done at hot zero power isothermal conditions and is not complicated by changes in the enthalpy rise or the presence of xenon. Conversion of the ITC to the MTC only requires subtracting the Doppler temperature coefficient from the ITC. Corrections can also be made for the difference between the measured and predicted C_B. for direct comparison to the predicted MTC. The BOL MTC measurements, along with the C_B measurements, are taken to verify the accuracy of the design model as well as demonstrate compliance with Technical Specifications.

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3.2 COMPONENTS CONSIDERED FOR EXEMPTION FROM THE MOST NEGATIVE MTC SR MEASUREMENT

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3.2.1 GLOBAL CORE REACTIVITY EFFECTS ON MTC

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3.2.2 AXIAL OFFSET EFFECTS ON MTC

The MTC is affected by the axial flux distribution via the impact the axial flux distribution has on the rate at which the moderator is heated as it flows up the core and by the axial flux weighting on different axial regions of the core. For a constant core temperature rise, a bottom skewed power distribution will cause the moderator entering the core to be heated faster. Since more heat is being added near the bottom of the core, more of the core will be at a higher moderator temperature slightly increasing core average moderator temperature. This increase in the core average moderator temperature will cause the MTC to be more negative.

In general, the accumulated burnup in the bottom half of the core exceeds the burnup in the top half of the core. Other things being equal, a higher burnup results in a more negative MTC as a result of isotopic effects on the flux spectrum. A more bottom skewed axial power shape, as indicated by a more negative axial flux difference (AFD), allocates a greater flux weighting, or importance, to the lower region of the core where the burnup is greater, thereby accentuating the burnup effect on MTC.

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3.2.3 MTC PREDICTIVE CAPABILITY

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3.3 APPLICATION OF THE 300 PPM SR MEASUREMENT CONDITIONAL EXEMPTION METHODOLOGY

3.3.1 BASIS OF THE METHODOLOGY

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3.3.2 BENCHMARK CRITERIA FOR METHODOLOGY APPLICATION

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3.3.3 APPLICATION OF THE CONDITIONAL EXEMPTION METHODOLOGY

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Table 3-1. Summary of Statistics for Measured Minus Predicted Differences of Critical Boron, MTC and Rod Worths for Westinghouse Cores

Parameter	Mean	Std. Dev.	No. Pts.
BOC HFP C_B	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
MOC HFP C_B	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
EOC HFP C_B	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
BOC HZP C_B	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
BOC HZP MTC	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
EOC HFP MTC	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}
BOC HZP Rod Worths	[ ]^{a,c}	[ ]^{a,c}	[ ]^{a,c}

Table 3-2. Benchmark Criteria for Application of the 300 PPM MTC Conditional Exemption Methodology

Parameter	Criteria
Assy. Power (Meas. Norm. Reaction Rate	± 0.1 or 10 %
Measured Incore Quardant Tilt (Low Power)	± 4 %
Measured Incore Quadrant Tilt (Full Power)	± 2 %
Core Reactivity (CB) Difference	± 1000 pcm
BOC HZP ITC	± 2 pcm/°F
Individual Control Bank Worth	± 15 %
Total Control Bank Worth	± 10 %

Table 3-3. Algorithm for Determining the Revised Predicted Near-EOL 300 PPM MTC

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Figure 3-1 Example of Predicted HFP ARO 300 ppm MTC Versus Cycle Burnup

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Figure 3-2 Difference Between Measured and Predicted 300 ppm Near-EOC Surveillance MTCs

4.0 SAFETY ANALYSIS IMPACT OF MOST NEGATIVE FEASIBLE MTC APPROACH

The accident analyses conservatively model the various reactivity coefficients to produce a bounding analysis. As discussed in Chapter 2, the applicable analyses assume a constant MDC to bound the predicted moderator reactivity insertion. The events which assume this value for EOL MDC are listed in Table 4-1.

As discussed in Reference 1, the reactivity coefficients assumed can have a strong influence on accident analysis results. Since the moderator coefficient can be affected by a reload, the conservative nature of the accident analysis assumption must be confirmed on a cycle-specific basis using the methodology discussed in Reference 1. This includes verification that the most adverse accident conditions of a constant MDC do not invalidate the conservative nature of the accident analysis assumption. This process ensures the ability to verify that the applicable safety limits are met for each reload design and, consequently, that the Technical Specifications are met.

Table 4-1. FSAR Chapter 15 Events Taht Assume A Constant Value of MDC

Section	Event
15.1.1	Feedwater System Malfunctions Causing a Reduction in Feedwater Temperature
15.1.2	Feedwater System Malfunctions Causing an Increase in Feedwater Flow
15.1.3	Excessive Increase in Secondary System Flow
15.2.2	Loss of External Load
15.2.3	Turbine Trip
15.2.8	Feedwater System Pipe Break
15.4.2	Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Powe
15.4.4	Startup of an Inactive Reactor Coolant Pump at an Incorrect Temperature
15.5.2	Chemical and Volume Control System Malfunction That Increases Reactor Coolant Inventory

5.0 CONCLUSIONS

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APPENDIX A. TECHNICAL SPECIFICATION REVISIONS WITH-COLR

SURVEILLANCE REQUIREMENTS

4.1.1.3 The MTC shall be determined to be within its limits during each fuel cycle as follows:

a. The MTC shall be measured and compared to the BOL limit specified in the COLR prior to initial operation above 5% of RATED THERMAL POWER, after each fuel loading; and

b. The MTC shall be measured at any THERMAL POWER and compared to the 300 ppm surveillance limit specified in the COLR (all rods withdrawn, RATED THERMAL POWER condition) within 7 EFPD after reaching an equilibrium boron concentration of 300 ppm[1]. In the event this comparison indicates the MTC is more negative than the 300 ppm surveillance limit specified in the COLR, the MTC shall be remeasured, and compared to the EOL MTC limit specified in the COLR, at least once per 14 EFPD during the remainder of the fuel cycle.

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[1] Measurement of the MTC in accordance to Specification 4.1.1.3.b may be suspended provided the benchmark criteria and the Revised Prediction as documented in the COLR are satisfied. Data required for the calculation of the Revised Prediction is provided in the Most Negative Moderator Temperature Coefficient Limit Report per Specification 6.9.1.7.

MOST NEGATIVE MODERATOR TEMPERATURE COEFFICIENT LIMIT REPORT

6.9.1.7 The most negative MTC limits shall be provided to the NRC Regional Administrator with a copy to the Director of Nuclear Reactor Regulation, Attention: Chief, Core Performance Branch, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, at least 60 days prior to the date the limit would become effective unless otherwise approved by the Commission by letter. This report will include the data required for the determination of the Revised Prediction of the 300 ppm/ARO/RTP MTC per WCAP-13749, "Safety Evaluation Supporting the Conditional Elimination of the Most Negative EOL Moderator Temperature Coefficient Measurement", May, 1993 (Westinghouse Proprietary).

APPENDIX B. COLR REVISION

2.3 Moderator Temperature Coefficient (LCO 3.1.1.3)

2.3.1 The Moderator Temperature Coefficient (MTC) limits are:

The BOL/ARO/HZP-MTC shall be less positive than ____ pcm/°F.

The EOL/ARO/RTP-MTC shall be less negative than ____ pcm/°F.

2.3.2 The MTC Surveillance limit is:

The 300 ppm/ARO/RTP-MTC should be less negative than or equal to ____ pcm/°F.

where: BOL stands for Beginning of Cycle Life
ARO stands for All Rods Out
HZP stands for Hot Zero THERMAL POWER
EOL stands for End of Cycle Life
RTP stands for RATED THERMAL POWER

2.3.3 The EOL MTC Revised Prediction shall be calculated from the algorithm defined in Table 3-3 of Reference ____ in Technical Specification 6.9.1.6.b. The MTC data required for this calculation shall be provided in a Most Negative Moderator Temperature Coefficient Limit Report per Specification 6.9.1.7. If the Revised Predicted MTC is less negative than the SR limit of _____ pcm/°F, and all benchmark criteria listed in Table 3-2 of Reference ____ are met, then a measurement is not required per Technical Specification 4.1.1.3.b.

NOTE: This report must be included in the COLR procedures in Technical Specification 6.9.1.6.b as the applicable reference for COLR Section 2.3.4. The Most Negative Moderator Temperature Coefficient Limit Report should also be specified in the references section of the COLR.

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APPENDIX C. TECHNICAL SPECIFICATION REVISIONS WITHOUT COLR

SURVEILLANCE REQUIREMENTS

4.1.1.3 The MTC shall be determined to be within its limits during each fuel cycle as follows:

a. The MTC shall be measured and compared to the BOL limit of Specification 3.1.1.3.a, above, prior to initial operation above 5% of RATED THERMAL POWER, after each fuel loading; and

b. The MTC shall be measured at any THERMAL POWER and compared to _____ pcm/°F (all rods withdrawn, RATED THERMAL POWER condition) within 7 EFPD after reaching an equilibrium boron concentration of 300 ppm[1]. In the event this comparison indicates the MTC is more negative than _____ pcm/°F, the MTC shall be remeasured, and compared to the EOL MTC limit of Specification 3.1.1.3.b, at least once per 14 EFPD during the remainder of the fuel cycle.

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[1] Measurement of the MTC in accordance to Specification 4.1.1.3.b may be suspended provided the benchmark criteria in Table 3-2 of WCAP-13610 and the Revised Prediction is less negative than _____ pcm/°F. The Revised Prediction is determined by the algorithm in Table 3-3 of WCAP-13749. Data required for this calculation is provided in the Most Negative Moderator Temperature Coefficient Limit Report per Specification 6.9.1.7.

MOST NEGATIVE MODERATOR TEMPERATURE COEFFICIENT LIMIT REPORT

6.9.1.7 The most negative MTC limits shall be provided to the NRC Regional Administrator with a copy to the Director of Nuclear Reactor Regulation, Attention: Chief, Core Performance Branch, U. S. Nuclear Regulatory Commission, Washington, D. C. 20555, at least 60 days prior to the date the limit would become effective unless otherwise approved by the Commission by letter. This report will include the data required for the determination of the Revised Prediction of the 300 ppm/ARO/RTP MTC per WCAP-13749, "Safety Evaluation Supporting the Conditional Elimination of the Most Negative EOL Moderator Temperature Coefficient Measurement", May, 1993 (Westinghouse Proprietary).

APPENDIX D. MOST NEGATIVE MODERATOR TEMPERATURE COEFFICIENT LIMIT REPORT

PURPOSE:

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PRECAUTIONS AND LIMITATIONS:

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PROCEDURE:

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Table D-1. (Table 1) Benchmark Criteria for Application of the 300 PPM MTC Conditional Exemption Methodology

Parameter	Criteria
Assy. Power (Meas. Norm. Reaction Rate	± 0.1 or 10 %
Measured Incore Quardant Tilt (Low Power)	± 4 %
Measured Incore Quadrant Tilt (Full Power)	± 2 %
Core Reactivity (CB) Difference	± 1000 pcm
BOC HZP ITC	± 2 pcm/°F
Individual Control Bank Worth	± 15 %
Total Control Bank Worth	± 10 %

Table D-2. (Table 2) Algorithm for Determining the Revised Predicted Near-EOL 300 PPM MTC

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Table D-3. (Table 3) Example Worksheet for Calculating the Revised Predicted Near-EOL 300 PPM MTC

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Figure D-1 (Figure 1) Predicted HFP ARO 300 ppm MTC Versus Cycle Burnup

REFERENCES

1. Davidson, S. L., Kramer, W. R., *Westinghouse Reload Safety Evaluation Methodology*, WCAP-9272-P-A (Westinghouse Proprietary), July 1985.

2. Nguyen, T. Q., et al., *Qualification of the PHOENIX-P/ANC Nulcear Design System for Pressurized Water Reactor Cores*, WCAP-11596-P-A (Westinghouse Proprietary), June 1988.

3. Liu, Y. S., *ANC: A Westinghouse Advanced Nodal Computer Code*, WCAP-10965-P-A (Westinghouse Proprietary), December 1985.

4. *Reload Startup Physics Tests for Pressurized Water Reactors*, ANSI/ANS-19.6.1.1985, December 1985.

5. *Core Operating Limits Report License Amendment Submittal*, ESBU/WOG-89-149, September 1989.

SECTION F

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

August 4, 1994

Mr. Nicholas J. Liparulo, Manager
Nuclear Safety and Regulatory Activities
Westinghouse Electric Corporation
P.O. Box 355
Pittsburgh, PA 15230-0355

Dear Mr. Liparulo:

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION FOR WESTINGHOUSE TOPICAL REPORT WCAP-13749 (TAC NO. M85837)

REFERENCE: WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement"

We have reviewed your report referenced above. The Enclosure to this letter is our request for additional information needed to complete our evaluation. Please provide responses to these questions within 45 days so that the review may continue on schedule. Please contact H. Richings if you need further clarification of our request.

Timothy E. Collins /for
Robert C. Jones, Chief
Reactor Systems Branch
Division of Systems Safety and Analysis

Enclosure:
As stated

Contact: H. Richings, SRXB/DSSA
504-2888

<u>ADDITIONAL INFORMATION REQUIRED for the</u>
<u>REVIEW of the WESTINGHOUSE TOPICAL REPORT WCAP-13749</u>

1. Describe the magnitude of the conservatism included in the design MTC relative to the MTC (equivalent) value used in the FSAR analyses. Does this conservatism depend on the specific transient being analyzed and on the reload core design? How does this conservatism compare to the (2-sigma) uncertainty of the PHOENIX-P/ANC EOL HFP ARO MTC prediction?

   If credit for this conservatism is being taken, as indicated in Section-3.2, how will the required conservatism be maintained from cycle-to-cycle, and how will this be documented for each reload cycle?

   If credit for this conservatism is going to be used to account for the EOL MTC calculational uncertainty, describe the relationship between: (1) the MTC value used (or implicit) in the FSAR analyses, (2) the MTC calculated for the specific reload design core, (3) the Technical Specification Surveillance Requirement (SR) limit used for comparison with the Revised Predicted MTC (to allow suspension of the EOL MTC measurement), and (4) the 95/95 upper tolerance limit determined by the EOL MTC calculation-to-measurement differences. How will these values be combined to insure an appropriately conservative Technical Specification SR limit?

2. In view of the large difference between the EOL HFP and BOL Hot-Zero-Power (HZP) moderator temperature coefficients (typically, ~ - 30.0 pcm/°F versus 0.0 pcm/°F, respectively) and the substantially different effects contributing to these two coefficients (e.g., xenon, enthalpy rise, boron concentration, fuel burnup, doppler feedback and power distribution), provide the basis for applying a BOL HZP calculation-to-measurement bias to the EOL HFP MTC prediction.

3. Are the spectral effects associated with changes in the water scattering kernel temperature included in the conversion of the FSAR Moderator Density Coefficient (MDC) to an equivalent moderator temperature coefficient?

4. Is there any dependence of the Table 3-1 MTC comparisons on the core or fuel design parameters? Do the calculation-to-measurement differences depend on cycle length?

5. Why isn't an uncertainty allowance included in the EOL MTC predictive correction (along with the bias) to account for the observed differences between the MTC predictions and measurements?

6. In view of the large difference in the magnitude of the BOC MTC and EOC MTC, why isn't the predictive correction determined from the BOC MTC applied on a percent basis?

7. What is the typical sensitivity of the EOL (300 ppm) HFP MTC to Axial Flux Difference (AFD), and what is the range of the typical AFD corrections?

8. How will the benchmark criteria of Table 3-2 be confirmed? At what frequency will the various criteria of Table 3-2 be verified during the cycle? Will calculation-to-measurement differences that are outside these limits be allowed?

9. A major difficulty in the EOL MTC measurement results from the variation in the core operating statepoint variables. What is the effect on the EOL Hot-Full-Power (HFP) Moderator Temperature Coefficient (MTC) of expected variations in boron concentration, xenon concentration and distribution, fuel temperature and enthalpy rise?

10. The accuracy statistics of Table 3-1 are for the PHOENIX-P/ANC design system. Is the WCAP-13749 methodology only intended for applications with this code system?

SECTION G

Westinghouse Electric Corporation
Energy Systems

Box 355
Pittsburgh Pennsylvania 15230-0355

January 16, 1995
NTD-NRC-95-4384

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

Attention: R. C. Jones, Chief
Reactor Systems Branch
Division of Engineering and Systems Technology

Subject: Responses to Request for Additional Information on WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement" [Proprietary]

References: (1) Letter from R. C. Jones (NRC) to N. J. Liparulo (Westinghouse), Request for Additional Information on WCAP-13749, August 4, 1994

Dear Mr. Jones:

Enclosed are fifteen (15) copies [Proprietary] in response for additional information requested in Reference 1.

This submittal contains Westinghouse proprietary information of trade secrets, commercial or financial information which we consider privileged or confidential pursuant to 10 CFR 9.5(4). Therefore, it is requested that the Westinghouse proprietary information attached hereto be handled on a confidential basis and be withheld from public disclosure.

This material is for your internal use only and may be used solely for the purpose for which it is submitted. It should not be otherwise used, disclosed, duplicated, or disseminated, in whole or in part, to any other person or organization outside the Office of Nuclear Reactor Regulation without the expressed prior written approval of Westinghouse.

Correspondence with respect to any Application for Withholding should reference AW-95-771 and should be addressed to N. J. Liparulo, Manager of Nuclear Safety Regulatory and Licensing Activities, Westinghouse Electric Corporation, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

Nicholas J. Liparulo, Manager
Nuclear Safety Regulatory and Licensing Activities

cc: L. W. Barnett, NRC (MS 12H5)
L. E. Phillips, NRC (MS8E23)
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January 16, 1995
AW-94-771

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

Attention: Mr. R. C. Jones, Chief Reactor Systems Branch, Division of Engineering and Systems Technology

Reference: Letter from N. J. Liparulo (Westinghouse) to R. C. Jones (NRC), NTD-NRC-95-4384, January 16, 1995

Subject: Responses to Request for Additional Information on WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement" [Proprietary]

Dear Mr. Jones:

The above referenced letter contains information proprietary to the Westinghouse Electric Corporation.

The material will not be employed as a part of a license application or other action identified in 10CFR2.790(a) at this time. It will be separately submitted with an Application for Withholding accompanied by an Affidavit meeting the requirements of 10CFR2.790(b) prior to such use.

Accordingly, we request that the material be treated as proprietary information within the provisions of 10CFR9.5(4), "Freedom of Information Act Regulations." If there is a need to make public disclosure of the material prior to a separate Westinghouse submittal for docket in accordance with the provisions of 10CFR2.790(a), please notify Westinghouse prior to making a disclosure determination.

Correspondence with respect to the proprietary aspects of this submittal should reference AW-95-771 and should be addressed to the undersigned.

Very truly yours,

/for

Nicholas J. Liparulo, Manager
Nuclear Safety Regulatory and Licensing Activities

cc: Kevin Bohrer / NRC (12H5)

The following are responses to questions received from the USNRC regarding WCAP-13749, "Safety Evaluation Supporting the Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement"[1]. These questions are repeated below, and were previously documented in an USNRC letter from R. C Jones to N. J. Liparulo, dated August 4, 1994[2].

Q1 Describe the magnitude of the conservatism included in the design MTC relative to the MTC (equivalent) value used in the FSAR analyses. Does this conservatism depend on the specific transient being analyzed and on the reload core design? How does this conservatism compare to the (2-sigma) uncertainty of the PHOENIX-P/ANC EOL HFP ARO MTC prediction?

If credit for this conservatism is being taken, as indicated in Section-3.2, how will the required conservatism be maintained from cycle-to-cycle, and how will this be documented for each reload cycle?

If credit for this conservatism is going to be used to account for the EOL MTC calculational uncertainty, describe the relationship between: (1) the MTC value used (or implicit) in the FSAR analyses, (2) the MTC calculated for the specific reload design core, (3) the Technical Specification Surveillance Requirement (SR) limit used for comparison with the Revised Predicted MTC (to allow suspension of the EOL MTC measurement), and (4) the 95/95 upper tolerance limit determined by the EOL MTC calculation-to-measurement differences. How will these values be combined to insure an appropriately conservative Technical Specification limit?

A1 The magnitude of the conservatism between the design MTC (EOL, HFP, ARO, 0 ppm; i.e. the Limiting Condition for Operation or LCO) and the MTC (equivalent) value assumed in the FSAR analyses is dependent on the constant moderator density coefficient (MDC) assumed during the transients, the licensing basis for the LCO, and to some extent the HFP core average moderator temperature. Each of these items is described in Chapter 2 of WCAP-13749[1].

As stated in Section 2.1 of WCAP-13749[1], the FSAR accidents that form the basis for the Technical Specification most negative MTC LCO assume a conservatively bounding value of the MDC. For Westinghouse plants, the MDC assumed typically ranges from [$]^{a,c}$. The accidents which assume this constant MDC are listed in Table 4-1 of WCAP-13749[1] and are repeated here as Table 1.

The core conditions at which the bounding MDC exists depends upon the licensing basis of the most negative MTC LCO as described in Sections 2.2 through 2.4 of WCAP-13749[1]. The original basis assumed in the Westinghouse Standard Technical Specifications (STS) is the bounding MDC exists at HFP ARI (all rods inserted). This assumption is extremely conservative since this core condition is precluded by other Technical Specifications such as the rod insertion limits and peaking factors. The most negative MTC LCO is derived by converting the MDC to an equivalent MTC, and then subtracting out the incremental change in MTC associated with changing the core conditions from ARI to ARO. The conversion of MDC to MTC is accomplished by multiplying the MDC by the rate of change of moderator density with temperature at HFP conditions. This conversion rate can be obtained from standard steam tables and does not impose any undue conservatism. The 300 ppm Technical Specification Surveillance Requirement (SR) limit is derived by adding [ ]^{a,c} to the LCO to conservatively account for the difference between the 0 ppm LCO and 300 ppm SR.

The second licensing basis assumed by several Westinghouse plants is the most negative feasible MTC conversion. This approach assumes [

]^{a,c}. The conversion from the FSAR analyses equivalent MTC to the most negative MTC LCO is accomplished by [

]^{a,c}. The 300 ppm SR limit is derived by adding approximately [ ]^{a,c} to the LCO to conservatively account for the difference between the 0 ppm LCO and 300 ppm SR. The exact value is plant specific and is derived by [

]^{a,c}.

The amount of margin between the safety analysis MDC (equivalent MTC) limit and the Technical Specification LCO is checked each cycle as part of the Westinghouse reload safety evaluation methodology[5]. The amount of margin between the design predicted MTC and the surveillance requirement limit will also be examined each cycle as part of the conditional exemption methodology as described in Section 3.3 of WCAP-13749[1].

For those Westinghouse plants with recent designs based on PHOENIX-P/ANC[3,4], there is typically a large amount of margin between the design MTC (predicted EOL, HFP, ARO 0 ppm) and the MTC equivalent to the assumed safety analysis MDC. On the average, there is approximately a [ ]^{a,c} difference between the MTC equivalent to the assumed safety analysis MDC and the MTC calculated at the core conditions assumed in the safety analysis basis (i.e. HFP ARI or feasible most negative conditions). In addition, there is also an average of [ ]^{a,c} difference between the MTCs calculated at the core conditions assumed in the safety analysis basis and the core conditions assumed for the most negative MTC LCO (i.e. EOL, HFP, ARO, 0 ppm). While this indicates that there is typically large margin available between the predicted LCO MTC and the MTC equivalent to the assumed safety analysis MDC, credit will ***NOT*** be taken for this margin. Instead, a conservative uncertainty (the **predictive correction** in WCAP-13749[1]) will be applied to the MTC predicted by the core model.

The **predictive correction** is included to account for the observed differences between the measured and predicted (M-P) MTCs. The M-P difference is due to two sources of error: the measurement error and the predictive error. The measurement error can be caused by not properly accounting for the variation of all the parameters which can impact MTC such as moderator temperature, soluble boron concentration, core power level / fuel temperature and flux / xenon distribution. At HZP, the errors in core power / fuel temperature and flux / xenon redistribution do not exist. During a HFP MTC measurement, small variations in core power of 1 - 2% can create a small xenon oscillation and axial flux redistribution, which is difficult to accurately track. For a HZP MTC measurement, the impact of such errors is minimized, relative to the HFP MTC measurement, since measurements are typically taken over a 5°F swing in moderator temperature. During HFP measurements, the temperature swing is typically only 2 to 3°F. This has the effect of doubling the HFP MTC measurement error. For example, not accounting for 1 ppm of a change in the soluble boron during the measurement would introduce an error of approximately 10 pcm in reactivity defect into the measurement. For the typical HZP measurement, this would translate into a 2 pcm/°F MTC error, however, for the typical HFP measurement, this would translate into a 4 pcm/°F MTC error.

The second source of the M-P difference, the predictive error, is a function of how well the core model can calculate the change in core reactivity as a function of varying the moderator temperature about a reference value. One of the key assumptions of the PHOENIX-P/ANC[3,4] design methodology is that the reference conditions for the core model and the cross-sections used in the model is HFP moderator and fuel temperatures and nominal xenon concentration. From this viewpoint, it is reasonable to assume that [

]^{a,c}.

To determine a conservative value for the **predictive correction**, the MTC M-P data obtained from the Westinghouse physics database will be used. This data is summarized in Table 2. Note that the MTC data listed in this table differs from that presented in Table 3-1 of WCAP-13749[1] in that the data included in Table 2 includes measurements taken since issuing WCAP-13749[1].

To determine the **predictive correction**, an examination of the HZP M-P data will first be made. As discussed in the previous paragraphs, it is assumed [

]^{a,c}. The [ ]^{a,c} HZP MTC M-P data points of Table 2 have been demonstrated to fall within a normal distribution per the ANSI standard methodology of Reference 7, with a M-P mean of [ ]^{a,c} and a standard deviation of [ ]^{a,c}. This distribution is illustrated in Figure 2. From this data, a 95/95 one-sided tolerance limit for the HZP **predictive correction** of [ ]^{a,c} can be calculated by not taking credit for [ ]^{a,c} and using a K-value of [ ]^{a,c}.

To derive the HFP **predictive correction**, consideration must be given to [

]^{a,c}

[

]^{a,c}. The core model's MTC uncertainty associated with each of these parameters is not expected to significantly change with core power or burnup. [

]^{a,c}. The HFP **predictive correction** can then be derived by [

]^{a,c}. This yields a HFP **predictive correction** of [ ]^{a,c}, which will be rounded up to [ ]^{a,c}.

To further support that [ ]^{a,c} is a reasonable value for the HFP **predictive correction**, consider the following. [

]^{a,c}.

In addition to [ ]^{a,c}, there are also problems associated with [

]^{a,c}

[

]a,c.

In summary, a HFP **predictive correction** of [ ]a,c will be applied to the 300 ppm HFP MTC predicted at the burnup of the measurement. The main conservatism of this number is [

]a,c.

To insure that the HFP **predictive correction** is always used for determining if the EOL MTC measurement exemption is justified, the methodology documented in Tables D-2 and D-3 of WCAP-13749[1] will be modified. These revised tables are included here as Tables 4 and 5.

Q2 **In view of the large difference between the EOL HFP and BOL Hot-Zero-Power (HZP) moderator temperature coefficients (typically, ~ -30.0 pcm/°F versus 0 pcm/°F, respectively) and the substantially different effects contributing to these two coefficients (e.g. xenon, enthalpy rise, boron concentration, fuel burnup, doppler feedback and power distribution), provide the basis for applying a BOL HZP calculation-to-measurement bias to the EOL HFP MTC prediction.**

A2 As part of the EOL MTC measurement conditional exemption, it is important to determine how the core physics model predicts the actual core performance. Model benchmark criteria are listed in Table 3-2 of WCAP-13749[1] and included here as Table 3. As part of the exemption methodology, the model calculated MTC is adjusted by the **predictive correction** in WCAP-13749[1], to account for model predictive uncertainties. The **predictive correction** will always be [ ]a,, even if the measured BOL HZP MTC is less negative (or more positive) than the predicted MTC.

The derivation of the **predictive correction** is described in detail in the answer to Question 1. At BOL HZP (i.e. startup), it is relatively easy to perform an MTC measurement since the core is at isothermal conditions without xenon. Inferring the MTC from this measurement is a simple matter of tracking the average change in core reactivity versus moderator temperature and subtracting the Doppler temperature coefficient. However, any MTC measurement at HFP is more difficult to perform since an accurate measurement requires the core power to remain virtually constant during the cooldown and heatup transients. If core power waivers by just a few percent, small amounts of xenon and flux redistribution will occur which are difficult to compensate for and can cause large errors in the measurement.

Therefore, the **predictive correction** is based on [

]^{a,c}.

Q3 Are the spectral effects associated with changes in the water scattering kernel temperature included in the conversion of the FSAR Moderator Density Coefficient (MDC) to an equivalent moderator temperature coefficient?

A3 As discussed in Answer 1, the conversion of the FSAR MDC to an equivalent MTC is accomplished by multiplying the MDC by the rate of change of moderator density with temperature at HFP conditions. This conversion rate can be obtained from standard steam tables. The spectral effects associated with a change in water density / temperature are directly accounted for in the calculation of the MTC / MDC performed by ANC[4].

Q4 Is there any dependence of the Table 3-1 MTC comparisons on the core or fuel design parameters? Do the calculation-to-measurement differences depend on cycle length?

A4 There has not been any noticeable trend in the calculated-to-measured differences shown in Table 3-1 of WCAP-13749[1] (repeated here as Table 2) relative to the core or fuel parameters or to the cycle length. The data in this table is representative of a large variety in core types (2, 3 and 4 loops), cycle lengths, moderator temperatures, enrichments and burnable absorber types.

Q5 Why isn't an uncertainty allowance included in the EOL MTC predictive correction (along with the bias) to account for the observed differences between the MTC predictions and measurements?

A5 As described in the Answers 1 and 2, the EOL MTC **predictive correction** is based [

]^{a,c}.

Q6 In view of the large difference in the magnitude of the BOC MTC and EOC MTC, why isn't the predictive correction determined from the BOC MTC applied on a percent basis?

A6 Typical MTCs at BOC are very close to [ ]a,c, where typical near-EOC SR MTCs are on the order of [ ]a,c. As discussed in Section 3.3.2 and shown in Table 3 (Table 3-2 of WCAP-13749(1)), certain benchmark criteria must be met before the conditional exemption methodology can be applied. One of these criteria is the ANSI/ANS(6) standard on the BOC HZP ITC (MTC) of ±2 pcm/°F. At EOC, this would be equivalent to [ ]a,c, but at BOC this difference would become very large and could easily exceed [ ]a,c. Therefore, it is more appropriate to apply the **predictive correction** on an absolute basis instead of a percent basis.

Q7 What is the typical sensitivity of the EOL (300 ppm) HFP MTC to Axial Flux Difference (AFD), and what is the range of the typical AFD corrections?

A7 For those plants where this sensitivity has already been calculated [ ]a,c, the results have always been bounded by a sensitivity of [ ]a,c. Typical MTC corrections due to measured versus predicted differences in AFD should be fairly small, on the order of [ ]a,c or less.

Q8 How will the benchmark criteria of Table 3-2 be confirmed? At what frequency will the various criteria of Table 3-2 be verified during the cycle? Will calculation-to-measurement differences that are outside these limits be allowed?

A8 All of the benchmark criteria of Table 3-2 in WCAP-13749(1) (included here as Table 3)are required to be met before applying the conditional exemption methodology. These criteria are confirmed from startup physics test results and routine HFP boron concentration and incore flux map surveillances taken during the cycle.

The frequency of the HFP measurements is dictated by the plant's Technical Specifications. For example, incore flux maps are generally taken once a month. Reactivity balance is confirmed on a more frequent basis using daily boron concentration measurements.

Calculation-to-measurement differences that are outside the limits given in Table 3 (Table 3-2 of WCAP-13749(1)) will generally preclude an exemption from the near-EOL MTC measurement. However, any measurement results that do fall outside this criteria will be carefully reviewed to determine the reason for the large difference before determining whether an MTC measurement is required.

Q9 A major difficulty in the EOL MTC measurement results from the variation in the core operating statepoint variables. What is the effect on the EOL Hot-Full-Power (HFP) Moderator Temperature Coefficient (MTC) of the expected variations in boron concentration, xenon concentration and distribution, fuel temperature and enthalpy rise?

A9 Each of the components stated in the question play an important role in impacting the EOL HFP MTC. Each component must be accurately accounted for to obtain a successful (i.e. accurate) MTC measurement. This is especially true since fairly small reactivity changes of typically less than 200 pcm are measured over temperature changes on the order of 3 to 5°F. It is therefore very important to maintain a steady core power throughout the measurement. For example, variations of a few percent in core power during two successive cooldown-heatup MTC measurements can initiate small xenon oscillations with a resultant small reactivity redistribution defect. A redistribution defect as small as 50 pcm will give an MTC measurement error of 10 pcm/°F if not properly accounted for. This phenomena has been observed in at least one measurement performed at a Westinghouse plant; see the example given in Answer 1. Small variations in power level will also cause small changes in fuel temperature and enthalpy rise, impacting Doppler feedback and axial offset during the measurement, and which must be carefully accounted for. Another source of measurement uncertainty can arise in the ability to maintain a constant boron concentration throughout the measurement, or in the ability to properly account for any deviations during the measurement. For example, small boron concentration variations of 5 ppm can change core reactivity by approximately 40 pcm. If not properly accounted for, this could produce a measurement error of about 8 to 10 pcm/°F.

Q10 The accuracy statistics of Table 3-1 are for the PHOENIX-P/ANC design system. Is the WCAP-13749 methodology only intended for applications with this code system?

A10 The data represented in Table 3-1 of WCAP-13749[1], repeated here as Table 2, is based on the PHOENIX-P/ANC methodology documented in References 3 and 4. As all current Westinghouse designs are performed with this code system, it is intended that the methodology of WCAP-13749[1] be applied only to those designs based on PHOENIX-P/ANC.

References

1. Fetterman, R. J., *Safety Evaluation Supporting The Conditional Exemption of the Most Negative EOL Moderator Temperature Coefficient Measurement*, WCAP-13749 (Westinghouse Proprietary), May, 1993.

2. R. C. Jones (USNRC) to N. J. Liparulo (Westinghouse), *Request for Additional Information for Westinghouse Topical Report WCAP-13749 (TAC No. M85837)*, August 4, 1994.

3. Nguyen, T. Q., et al., *Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores*, WCAP-11596-P-A (Westinghouse Proprietary), June 1988.

4. Liu, Y. S., *ANC: A Westinghouse Advanced Nodal Computer Code*, WCAP-10965-P-A (Westinghouse Proprietary), December 1985.

5. Davidson, S. L., Kramer, W. R., *Westinghouse Reload Safety Evaluation Methodology*, WCAP-9272-P-A (Westinghouse Proprietary), July 1985.

6. *Reload Startup Physics Tests for Pressurized Water Reactors*, ANSI/ANS-19.6.1-1985, December 1985.

7. *American National Standard Assessment of the Assumption of Normality (Employing Individual Observed Values)*, ANSI-N15.15-1974.

Table 1: FSAR Chapter 15 Events That Assume a Constant Value of MDC

Section	Event
15.1.1	Feedwater System Malfunctions Causing a Reduction in Feedwater Temperature
15.1.2	Feedwater System Malfunctions Causing a Increase in Feedwater Flow
15.1.3	Excessive Increase in Secondary System Flow
15.2.2	Loss of External Electrical Load
15.2.3	Turbine Trip
15.2.8	Feedwater System Pipe Break
15.4.2	Uncontrolled Rod Cluster Control Assembly Bank Withdrawal at Power
15.4.4	Startup of an Inactive Reactor Coolant Pump at an Incorrect Temperature
15.5.2	Chemical and Volume Control System Malfunction that Increases Reactor Coolant Inventory

From Table 4-1 of WCAP-13749[1].

Table 2: Summary of Statistics for Measured Minus Predicted Differences of Critical Boron, MTC and Rod Worths for Westinghouse Cores

a,c

Table 3: Benchmark Criteria for Application of the 300 PPM MTC Conditional Exemption Methodology

Parameter	Criteria
Assembly. Power (Measured Normalized Reaction Rate)	± 0.1 or 10 %
Measured Incore Quadrant Tilt (Low Power)	± 4 %
Measured Incore Quadrant Tilt (Full Power)	± 2%
Core Reactivity (C_B) Difference	± 1000 pcm
BOC HZP ITC	± 2 pcm/°F
Individual Control Bank Worth	± 15 %
Total Control Bank Worth	± 10 %

From Table 3-2 of WCAP-13749[1].

Table 4. (Table 2) Algorithm for Determining the Revised Predicted Near-EOL 300 PPM MTC(*)

a,c

[ ]

Table 5. (Table 3) Example Worksheet for Calculating the Revised Predicted Near-EOL 300 PPM MTC

a,c

a,c

Figure 1

a,c

Figure 2

a,c

[ ]

Figure 3

a,c

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