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Proj 710

MFN 04-026
March 4, 2004

U.S Nuclear Regulatory Commission
Document Control Desk
Washington, D.C. 20852-2738

Attention: Chief, Information Management Branch
Program Management
Policy Development and Analysis Staff

Subject: **Completion of Responses to MELLLA Plus AOO RAIs (TAC No. MB6157)**

By Reference 1, the NRC requested additional information (RAI) in order to support their review of the Licensing Topical Report (LTR) NEDC-33006P, Revision 1, *General Electric Boiling Water Reactor Maximum Extended Load Line Limit Analysis Plus.* The RAIs addressed by Reference 1 related to core and fuel performance and loss of coolant accident (ECCS-LOCA). The responses to a majority of these RAIs already were provided to the NRC in Reference 2. Enclosures 1 and 3 contain the remaining responses.

For your convenience, Enclosures 1 and 3 include both the responses previously provided in Reference 2, as well as the remaining (new) responses. In this way, all the responses to Reference 1 are provided in one letter for easy reference. The TRACG analysis files referenced in the response to RAI 22 was provided on a compact disk in Reference 1 and that compact disk is not included herein.

Many of the responses provided in Enclosures 1 and 3 contain proprietary information as defined by 10CFR2.790. GE customarily maintains this information in confidence and withholds it from public disclosure. A non-proprietary version of the requested information is provided in Enclosure 2.

The affidavit contained in Enclosure 4 identifies that the information contained in Enclosures 1 and 3 has been handled and classified as proprietary to GE. GE hereby requests that the information of Enclosures 1 and 3 be withheld from public disclosure in accordance with the provisions of 10 CFR 2.790 and 9.17.

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If you have any questions, please contact, Mike Lalor at (408) 925-2443 or myself.

Sincerely,

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Project No. 710

References:

1. MFN 04-007, Letter from Alan Wang (NRC) to James Klapproth (GE), January 29, 2004,. *Request for Additional Information - Licensing Topical Report NEDC-33006P, Revision 1, "General Electric Boiling Water Reactor Maximum Extended Load Limit Analysis Plus," (TAC No. MB6157)*

2. MFN 04-020 ,Letter from George Stramback (GE) to the NRC, February 27, 2004, *Response to MELLLA Plus AOO RAIs (TAC No. MB6157))*

Enclosures:

1. Response to NRC MELLLA+ AOO RAIs – Proprietary Information
2. Response to NRC MELLLA+ AOO RAIs – Non-Proprietary Information
3. Applicability of NRC Approved Methodologies to MELLLA+ - Proprietary Information
4. Affidavit, George B. Stramback, dated March 4, 2004

cc: B Pham (NRC)
AB Wang (NRC)
J Harrison (GE/San Jose)
JF Klapproth (GE/San Jose)
MA Lalor (GE/San Jose)
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ENCLOSURE 4

MFN 04-026

AFFIDAVIT

General Electric Company

AFFIDAVIT

I, George B. Stramback, state as follows:

(1) I am Manager, Regulatory Services, General Electric Company ("GE") and have been delegated the function of reviewing the information described in paragraph (2) which is sought to be withheld, and have been authorized to apply for its withholding.

(2) The information sought to be withheld is contained in Enclosures 1 and 3 to GE letter MFN 04-026, George Stramback to NRC, *Completion of Responses to MELLLA Plus AOO RAIs (TAC No. MB6157)*, dated March 4, 2004. The proprietary information in Enclosure 1, *Response to NRC MELLLA+ AOO RAIs*, is identified by a double underline inside double square brackets. Figures and large equation objects are identified with double square brackets before and after the object. The proprietary information in Enclosure 3, *Applicability of NRC Approved Methodologies to MELLLA+*, is the entirety of each page of the enclosure; therefore, the header of each page in this enclosure carries the notation "GE Proprietary Information. {3}." In each case, the superscript notation{3} refers to Paragraph (3) of this affidavit, which provides the basis for the proprietary determination.

(3) In making this application for withholding of proprietary information of which it is the owner, GE relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10 CFR 9.17(a)(4), and 2.790(a)(4) for "trade secrets" (Exemption 4). The material for which exemption from disclosure is here sought also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product;

c. Information which reveals aspects of past, present, or future General Electric customer-funded development plans and programs, resulting in potential products to General Electric;

d. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs (4)a., and (4)b, above.

(5) To address 10 CFR 2.790 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by GE, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by GE, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within GE is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his delegate), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside GE are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information identified in paragraph (2), above, is classified as proprietary because it contains detailed results and conclusions from evaluations of the safety-significant changes necessary to demonstrate the regulatory acceptability for the expended power/flow range of MELLLA+ for a GE BWR, utilizing analytical models and methods, including computer codes, which GE has developed, obtained NRC approval of, and applied to perform evaluations of transient and accident events in the GE Boiling Water Reactor ("BWR"). The development and approval of these system, component, and thermal hydraulic models and computer codes was achieved at a significant cost to GE, on the order of several million dollars.

The development of the evaluation process along with the interpretation and application of the analytical results is derived from the extensive experience database that constitutes a major GE asset.

(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to GE's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of GE's comprehensive BWR safety and technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology and includes development of the expertise to determine and apply the appropriate evaluation process. In addition, the technology base includes the value derived from providing analyses done with NRC-approved methods.

The research, development, engineering, analytical and NRC review costs comprise a substantial investment of time and money by GE.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

GE's competitive advantage will be lost if its competitors are able to use the results of the GE experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to GE would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive GE of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information, and belief.

Executed on this 4th day of March 2004.

George B. Stramback

George B. Stramback
General Electric Company

ENCLOSURE 2

MFN 04-026

Response to NRC MELLLA+ AOO RAIs

Redacted and Non-proprietary Information

Table of Contents

NRC RAI 1, Time Varying Axial Power Shapes (TVAPS)

a. [[

]]

b. (Based on the audit). Provide a background discussion on why the fuel channels experience axial power shape changes during pressurization transients. [[

]]

c. What are the principle factors that control the severity of ΔCPR response to TVAPS. Does the severity of the CPR change with TVAPS increase for the EPU/MELLLA operating condition? Explain the impact of the EPU/MELLLA+ condition on the factors that control the severity of the CPR change due to TVAPS effect. Would the effect of TVAPS on the ΔCPR be more severe for 55% CF, 80% CF, 100% CF along the MELLLA+ upper boundary or the EPU/ICF as an initial condition. Does the severity of the TVAPS effect on the CPR differ for different pressurization transient?

d. Amendment 27 to GESTAR II (submitted for staff review) states that "NRC-agreed upon methodology for evaluating GE11 and later fuel uses time varying axial power shape (TVAPS), thereby changing the need for assuring this check. See GENE-666-03-0393 and NRC staff agreement at meeting on April 14, 1993." Explain this statement and state if the NRC reviewed and approved the method used to check or account for the effect of TVAPS on the CPR change during pressurization transients.

e. If the method used to evaluate the effect of TVAPS during a pressurization transient was not reviewed by the staff in the supplement to Amendment 27, provide sufficient information, including sensitivity results so that the staff can review the method and the effects of TVAPS on the transient response for plants operating with the EPU/MELLLA+ core design.

Response

a. [[

]] This is described in GESTAR, Section 4.3.1.2.1.

b. Channels experience TVAPS primarily due to the reactor scram that occurs coincident with the power increase that occurs during a pressurization transient. This effect is described in GENE-666-03-0393. The ΔCPR result is a function of both the trend in the ODYN integral power or heat flux and TVAPS. [[

]] The dominant effect will dictate the ΔCPR.

c. [[

]] The sequence of events and resulting affect on steam quality is shown in GENE-666-03-0393.

[[

]]

d. Initially the NRC did not formally review and approve the method used to check or account for the effect of TVAPS on the CPR change, during pressurization transients. The NRC was first informed of the changes to the transient analysis procedure during a meeting on September 11, 1991. GE to US-NRC Letter MFN-140-91, "Pressurization Transient Analysis Procedures For GE11" [1], November 5, 1991 documents the meeting and provides a summary of the change to the analysis procedure. Subsequent to the GE11 Audit in March 1992, GENE-666-03-0393 [2,3] was provided to the NRC for information. The inclusion of the TVAPS effect in the analysis increases the conservatism in the analysis, which is an allowable change without NRC review per 10CFR50.59.

The use of TVAPS in the transient analysis is described the section 1 of the TASC Licensing Topical Report [4] and is also described in 4.3.1.2.1 of GESTAR II [5]. Since these documents are NRC approved, the use of TVAPS in the transient analysis process is considered NRC approved.

e. TVAPS is considered NRC approved (see the response to RAI 1.4). The effect of TVAPS is described in Reference 3 and the impact of operating conditions is discussed in the response to RAI 1.3.

References

1. J. S. Charnley (GE) to R. C. Jones (NRC), Pressurization transient Analyses procedures for GE11, MFN-91-038, November 5, 1991.
2. J. F. Klapproth (GE) to USNRC, Time Varying Axial Power Shape for pressurization Transients, MFN-069-93, May 3, 1993.
3. Impact of Time Varying Axial Power Shape on Pressurization Transients, GENE-666-03-0393, March 1993.
4. TASC-03A, A Computer program for Transient Analysis of a Single Channel, NEDC-32084P-A, Revision 2, July 200.
5. General Electric Standard Application for Reactor Fuel, GESTAR II, NEDE–24011–P–A–14, June 2000.

NRC RAI 2, TVAPS Effect for Brunswick

For the Brunswick EPU/MELLLA+ analyses, explain what method will be used to calculate TVAPS. According to the proposed Amendment 27 changes to Section 4.3.1.2.1 of GESTAR, the time varying axial power shape for GE 11 fuel and later products is calculated using ODYN. The staff has been informed that Progress Energy is using TRACG to perform the EPU/MELLLA+ reload analysis. As such, how does ODYN interface with TRACG? Based on the Brunswick EPU/MELLLA+ core, provide a description of how the TVAP effect on the CPR was accounted for and calculated. Provide plots of the results.

GE Response

The Brunswick-1 TRACG model includes a hot channel. NEDC-32906P-A, Revision 1,*TRACG Application for Anticipated Operational Occurrences (AOO) Transient Analysis*, Section 8.1 describes the channel grouping process. Since the hot channel is integral to the TRACG 3D-Kinetic method, the hot channel includes all same boundary conditions that are used in the ODYN/TASC method (although the TRACG hot channel flow is driven from the plenum-to-plenum pressure drop). The TVAPS is obtained from the 3D prediction of the hot channel power. Figures AOO-2-1 through AOO-2-4 provides the same time histories as provided in Figure 8-3 through 8-6 in NEDC-32906P-A but for Bunswick-1 Cycle 15 at MELLLA+ conditions.

[[

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Figure AOO-2-1. TRACG M+ Power and Flow Response for TTNB Event

[[

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Figure AOO-2-2. TRACG M+ CPR Response for TTNB Event

[[

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Figure AOO-2-3. TRACG M+ Pressure and Relief Valve Response for TTNB Event

[[

]]

Figure AOO-2-4. TRACG M+ Vessel Inlet and Exit Flow for TTNB Event

NRC RAI 3. [[

a.

b.

]]

i the performance and accuracy of the results obtained from the codes used to perform core response, during steady state, transients, and accidents (e.g., TRACG, ODYN/ISCOR/PANCEA),

ii the CPR response for all events,

iii the calculation of the moister carryover and carryunder, and

iv bundle level.

c. [[

]] Explain how this modeling technique affects the accuracy of the corresponding results. State whether the effect [[

]]

d. [[ ]] detect and suppress instability response and the ATWS instability response. [[

]] please reanalyze all supporting cases.

e.]] the ATWS instability, the detect and suppress instability, and the anticipated operational occurrence (AOO) analyses. For each event type, discuss what impact the water rod flow would have on the plant's response in terms of the parameters that are important in each phenomenon of interest. [[ ]]

GE Response

Response to part a

[[

]]

<u>Response to part b</u>
The impact of [[

]] The response to RAI #5 has shown that bypass voiding is not significant for the MELLLA+ region of operation. Therefore, the water rod modeling assumptions are not challenged for steady-state and transient calculations, CPR response, and bundle level. The accuracy of moisture carryover and carryunder are related to steam separator performance and not directly related to bypass and water rod flow modeling.

However, the following information is provided to clarify the water rod and out channel flows modeling assumptions:

- [[

  ]] The effects of MELLLA+ on bypass voids as simulated by ISCOR is provided in the response to RAI 5b.

  [[

-

  ]]

- TRACG has a large degree of modeling flexibility. In particular, [[

]] In particular, the TRACG analysis for the Brunswick MELLLA+ evaluations model [[
]]

Response to part c
See the response to RAI 3b.

Response to part d
Detect and Suppress Instability
The Detect and Suppress instability analysis using TRACG [[
]] (e.g. TRACG analysis documented in NEDC-33075P Rev 3, January 2004).

ATWS Instability
TRACG analysis was performed to address [[
]] The event was initiated at 120% OLTP and 70% rated core flow statepoint. For the evaluated plant, this rated core power to flow ratio is 52.5 MW/Mlb/hr in absolute units, which is bounding of all plants expected to implement MELLLA+.

[[
]]

Response to part e
TRACG ATWS:
[[

]]

NRC RAI 4, Effects of Bypass Voiding

The operation at higher power at reduced core flow, the flatter power profile, and the over 24 percent higher steam flow during EPU/MELLLA+ operation may result in increased voiding in the upper bypass region, which affects both the low power range monitor (LPRM) and the traversing in-core probe (TIP) detector response. The effect of bypass voiding on the instrumentation is not random (and therefore cannot be combined with random uncertainties to determine an increase in uncertainty), but rather is a systematic effect which can bias the detector response. Therefore, the effect of bypass voiding on the core performance code systems (e.g., MONICORE - minimum critical power ratio (MCPR), linear heat generation rate (LHGR) and safety systems (e.g., average power range monitor, rod block monitor) which receive input from this instrumentation should be evaluated.

a. Provide an evaluation of the potential for bypass voiding for the EPU and EPU/MELLLA+ operation. Describe how the bypass voiding affects the accuracy of the core monitoring instrumentation.

b. Explain the bases for the [[ ]]

c. Identify the codes and the corresponding models that would be affected by [[ ]] Explain the impact of bypass voiding on the accuracy and the assumptions of the codes and the corresponding models used to simulate the boiling water reactor (BWR) response during steady state, transient, or accident conditions.

d. [[ ]] but would not be predicted by the core simulator. Evaluate the effect of potential errors introduced by [[ ]]

e. Supplement the MELLLA+ application to evaluate the potential and effects of bypass voiding. The supplement should provide sufficient justification and supporting sensitivity analyses to conclude that bypass voiding for the EPU and EPU/MELLLA+ will remain within an acceptable limit.

GE Response

4a. Please see the response to RAI 3a and RAI 5b for the magnitude of impact of MELLLA+ on bypass voiding. The impacts of bypass voiding on core monitoring uncertainties are covered in the Response to RAI 6e.

4b. LPRM uncertainty increases with increasing void. LPRM specifications limit the presence of void to [[ ]]

4c. See the response to RAI 6e.

4d. The validity of assumptions regarding [[ ]] is discussed in the response to RAI 3b.

4e. For additional information on the sensitivity of bypass voiding on analyses for MELLLA+ are discussed in the response to RAI 6e.

NRC RAI 5, Bypass Voiding for Brunswick and Clinton

a. State whether Brunswick and Clinton are gamma tip plants. Gamma tip LPRMs are sensitive to bypass voiding.

b. Based on the MELLLA+ core design and the most limiting core power profile and hot bundle power condition, determine whether Brunswick and Clinton would experience bypass voiding. [[ ]]
Perform the evaluation at the different statepoints on the EPU/MELLLA+ upper boundary. Specifically, demonstrate that the bypass voiding would remain below [[ ]] for operation at the 55 percent CF and the 85 percent core flow statepoints.

c. [[ ]] justify why the predicted bypass voiding is accurate. Provide similar justifications for the TRACG analyses.

d. If the predicted bypass voiding is within the acceptable range, [[ ]] Suggest procedures or methods for checking this parameter during the reload. This is particularly important [[ ]] which could invalidate some of the analytical methods and affect the accuracy of the monitoring instrumentation.

GE Response

5a. Both Brunswick units (BWR/4) use gamma sensitive TIPs while Clinton (BWR/6) use thermal neutron TIPs.

5b The following are bounding (based on 4 bundle average power) ISCOR results for Brunswick and Clinton at the two points:

[[		
		]]

The predicted bypass voids are within [[ ]].

5c. As demonstrated in the response to RAI 5(b), the assessment of bypass voiding at the MELLLA+ condition has been performed using ISCOR, [[ ]] This assessment has shown that any significant bypass voiding will not occur in the MELLLA+ condition. Therefore, the validity of the [[ ]] models for PANACEA or TRACG application is not challenged. For more information, please see the responses to RAI 3(b) and RAI6(e).

5d. The plant specific applications performed thus far indicate that bypass voiding exceeding [[ ]] will not occur at the MELLLA+ boundary. For safety and licensing analysis verification, a check on bypass voiding will be implemented. However, as indicated in the response to RAI 6(e), methods adequacy will be confirmed following plant application of MELLLA+.

NRC RAI 6, Void Fractions Greater than 90 Percent
The Brown Ferry steady state TRACG analysis shows that the hot channel exit void fraction is greater than 90 percent. This could potentially affect the validity of the exit conditions assumed in the computational models used to perform the safety analyses. The audit documents indicates that GENE had evaluated the effect of the high exit void fraction on the analytical models, techniques and methods. However, the evaluations and the bases of the conclusions were not discussed in the MELLLA+ LTR or submitted for NRC review as an amendment to GESTAR II. The following RAIs address the effect of the high exit void fraction and quality on the EPU/MELLLA operation.

a. Provide an evaluation of the analytical methods that are affected by the hot channel high exit void fraction (>90 percent) and channel exit quality. Discuss the impact the active channel exit void fraction would have on:

   i. the steady-state nuclear methods (e.g., PANAC/ISCOR),
   ii. the transient analyses methods (e.g., ODYN/TASC/ODSYS),
   iii. the GEXL correlation, and
   iv. the plant instrumentation and monitoring.

b. Evaluate whether the higher channel void fraction would affect any benchmarking or separate effects testing performed to assess specific thermal-hydraulic and/or neutronic phenomena.

c. Include in your evaluation, the effect of the high void fractions on the accuracy and assessment of models used in all licensing codes that interface with and/or are used to simulate the response of BWRs, during steady state, transient, and accident conditions.

d. Submit an amendment to the appropriate NRC-approved codes (e.g., TRACG for AOO, ODYN/ISCOR/TASC, SAFER/GESTR/TASC, ODSYS) that updates and evaluates the impact of the EPU/MELLLA+ operating conditions such as the high exit void fraction on the computational modeling techniques and the applicability range.

e. Submit a supplement to the MELLLA+ LTR that addresses the impact of the EPU/MELLLA+ core operating conditions, including high exit void fraction, on the applicability of the currently approved licensing methods.

GE Response
6 a, b, c Please see the documentation associated with the response to RAI 6e.

6d Licensing topical reports for NRC approved methodologies such as ODYSY (NEDC-32992P-A, July 2001) were submitted as generic methods reports and remain correct as written. MELLLA+ is an expansion of the range of application of these methodologies,. Therefore, the methods were examined and documented collectively, not individually, per common practice for new applications. Evidence of this examination is provided in the response to RAI 6e.

6e Enclosure 3, Applicability of NRC Approved Methodologies to MELLLA+, has been provided which supplies technical evaluation of key technical models used within the NRC licensed methodologies as well as summary statements on the NRC licensed methodologies themselves. This information has been provided to demonstrate the applicability of the GE methodology to the MELLLA+ operating range.

Tables 6-1 and 6-2 summarize the evaluations performed and the conclusions reached. The "Steady-State Nuclear Methods" items are fundamental models, which may affect all methods employed by GE. The other items are more specific in their scope to transient analysis, GEXL, and SLMCPR.

Table 6-1

Enclosure Section	**Item**	**Assessment**
	Steady-State Nuclear Methods	
2.1	Extrapolation of lattice parameters to in-channel 90% Void Fraction	The technique of fitting the lattice physics data [[ ]] There is no substantial change of this assumption for MELLLA+ operating strategies. [[ ]] For these reasons, confirmation of eigenvalue tracking will be executed for the plants operating with MELLLA+ per standard procedure. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy. See item 2.5 for disposition of derivative parameters.
2.2	Void-Quality Correlation	The use of the GE standard model is adequate for modeling pressure drop for the MELLLA+. The database supporting the void correlation in use by the ECPs sufficiently covers the MELLLA+ operating range.
2.3	Flow Distribution Models	The upper plenum pressure is nearly uniform at MELLLA+ such that steady-state bundle flow will not be impacted. The database supporting the pressure drop in use by the ECPs sufficiently covers the MELLLA+ operating range.
2.4	Diffusion Theory	The method is adequate. Confirmation of eigenvalue tracking will be executed for the plants operating with MELLLA+ per standard procedure. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy.

Table 6-1		
Enclosure Section	**Item**	**Assessment**
2.5	1 ½ Group Assumption	The method is adequate. There is no substantial change of this assumption in going from MELLLA to MELLLA+ operating strategies. [[ ]] Confirmation of eigenvalue tracking will be executed for the plants operating with MELLLA+ per standard procedure. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy.
2.6	Spectral History Impacts of Extended High Void Operation	The method is adequate. The dominant spectral effect in MELLLA+ of physical void history is included in PANACEA. The use spectral history model of PANAC11 is an additional improvement since it makes a correction to the nuclear library lookup process to account for effects due to hardened spectrum separate from void history.
2.7	Direct Moderator Heating Model	The method is adequate. MCNP calculations show that [[ ]] Additionally, the [[ ]] of the current model is confirmed at the higher void fractions associated with MELLLA+.
2.8	Bypass Void Models	The method is adequate for MELLLA+ application. Even if [[ ]] were to occur at the D level LPRM, the resulting nodal power error is about [[ ]] and the impact on bundle power is negligible. Confirmation of eigenvalue tracking will be executed for the plants operating with MELLLA+ per standard procedure. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy.
2.9	[[ ]]	[[ ]]

Table 6-1		
Enclosure Section	**Item**	**Assessment**
2.10	TIP/LPRM Correlations	The method is adequate. Use of TIP/LPRM correlations at high in-channel void conditions or with known bypass voiding up to [[ ]] does not introduce errors in the instrument interpretation larger than that already in the experience base.
	Transient Analysis Methods	
3.1	Steam separator model performance at high qualities	Adequacy of the current transient analysis methodology with respect to steam separator performance is acceptable for MELLLA+ conditions. Continued use of conservative assumptions regarding carryunder and carryover fractions is recommended.
3.2	High power/low flow ratio	The method is adequate based on evaluations of 2.2, 2.4, 2.7, 2.8, 2.9, and 3.1.
3.3	Time and Depth of Boiling Transition	The method is adequate. The accuracy is acceptable.
	GEXL Correlation	
4.0	Database may not have data to support over 90% void fraction operation. Significant operation may occur at off-rated conditions	The method is adequate. The GEXL correlation application range concern covers MELLLA+ conditions. The correlation is based on a range of power shapes that cover the expected range of application for MELLLA+.
	Plant Instrumentation & Monitoring	
5.1	D Level LPRM Void will cause reading uncertainty	The method is adequate for licensing. See 2.8 and 2.10. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy.
5.2	Review GETAB and Reduced SLMCPR Uncertainties	The method is adequate for licensing. Confirmation of thermal limits uncertainties (e.g., power distribution) will be executed for initial implementation of MELLLA+ strategy.

For additional clarification, the following table provides a cross reference of applicable NRC approved methodologies (Reference 1) and the areas of concern for MELLLA+ operation.

Table 6-2									
IMPACT AREA\ METHODOLOGY	TGBLA	PANACEA	ISCOR	ODYN	TASC	ODYSY	SAFER	TRACG	SLMCPR
Steady State Nuclear Methods	[[								
Extrapolation of XS to 90% Void									
Void Quality Correlation									
Flow Distribution Models – Pressure Drop									
Diffusion Theory									
1.5 Group Assumption									
Spectral History Impacts									
Direct Moderator Heating Model									
Bypass Void Models									
[[ ]]									
TIP/LPRM Correlations									
Transient Analysis Methods									
Steam Separator Model									
High Power/Low Flow Ratio									
Time/Depth of Early BT									
GEXL Correlation									
Database over 90% Void									
Off-rated Conditions									
Plant Instrumentation & Monitoring									
D LPRM Level Void Uncertainty									
SLMCPR Uncertainties									]]

The final technical conclusion is that GE has systematically examined its NRC approved methodologies with regard to operation in the MELLLA+ domain. GE has found that these methods are adequate.

However, GE believes that methodology performance within the MELLLA+ operating domain be examined carefully once a significant set of plant data is available. [[

]] In addition, while no licensing issues have been determined to be outstanding regarding the methods and their application ranges, a recommendation that the thermal limits uncertainties be confirmed for the initial implementation of the MELLLA+ strategy applies to the technology areas. This confirmation should include [[

]] in NEDC-32694P-A. Also at the time of implementation, the [[ ]] will be reviewed as per the NRC instruction in NEDC-32601P-A.

NRC RAI 7, Brunswick and Clinton - Effect of Void Fractions Greater than 90 Percent

a. Explain how the core averaged void fraction reported in the heat balance table is computed. For example, the Brunswick MELLLA+ application reports core averaged void fractions in the range of 0.51 to 0.54 for different statepoints.

b. For the EPU/MELLLA+ core design, what is the hot channel exit void fraction for the steady state operation at the EPU 120 percent power/99 percent CF, EPU/MELLLA+ 120 percent power/85 percent CF and the EPU/MELLLA+ 77.6 percent power/55 percent CF statepoints? Use bounding conditions.

GE Response

a. This value is the active coolant average void fraction. The bypass and unheated regions are not included in this average.

$$<VF> = \frac{\displaystyle\sum_{i=1}^{\#\,each\,type} n_i \frac{\sum_{k=1}^{24} VF_k FlowArea_k}{24 <FlowArea>}}{Total\ \#\ of\ Bundles}$$

, where i is the ISCOR channel types and k is the axial nodes.

b. The following are results for Brunswick 1, Cycle 15 at the MOC transient point.

[[		
		]]

Note, values at 120% / 104.5% are provided instead of 120% / 99% to provide the full range of void fractions with licensed core flow.

NRC RAI 8, ICF

Are the shutdown margin, standby liquid control system shutdown capability and mislocated fuel bundle analyses performed at the rated conditions (100 percent EPU power/100 percent CF). If so, justify why these calculations are not performed for the nonrated conditions such as the ICF condition. Provide supporting sensitivity analysis results for your conclusions or update the GESTAR II licensing methodology, stating that these calculations would be performed at the ICF statepoint.

GE Response

These analyses are performed for each reload core design to confirm that the acceptance criteria documented in GESTAR-II is met.

a. SDM and SLCS

These analyses confirm that acceptable reactivity margins exist in the core throughout the cycle.
[[

]] The analyses are not performed at rated conditions.

b. Mislocated Bundle

This analysis confirms that the fuel thermal margins for the worst postulated fuel load mislocation are within those acceptable for AOOs. [[

]] The analysis is not performed at rated conditions.

NRC RAI 9

The hot channel void fraction increases with decreasing flow along the MELLLA+ upper boundary. Therefore, the void fraction at the 55 percent CF and the 80 percent CF statepoints are higher than the void fraction at 99 percent CF. Consequently, it is feasible that the initial conditions of the hot channels could be higher at the minimum core flow statepoints or at the offrated conditions.

a. Justify why the steady-state initial critical power ratio (ICPR) is assumed in determining the offrated AOO response, instead of the ICPR calculated from offrated conditions.

b. For the most bounding conditions, compare the steady-state ICPR calculated based on the actual conditions at the state points (rated, 80 percent CF, and 55 percent CF or offrated lower power and flow conditions).

GE Response

a. [[

]]

b. The ICPR associated with the results in Table 9-2 of the M+ LTR is as follows:

[[		
		]]

The offrated ICPR at 55% core flow is as follows:

[[		
		]]

[[

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NRC RAI 10, ISCOR/ODYN/TASC Application

The transient CPR and the peak cladding temperature (PCT) calculations are performed using the ODYN/ISCOR/TASC combination. The staff understands that ISCOR calculates the initial steady-state thermal-hydraulic core calculations. ODYN (1-D code) provides the reactor power, heat flux, core flow conditions, and the axial power shapes of the hot bundle during the transient. [[

]] The ISCOR/TASC combination is also used to calculate the PCT for ECCS-LOCA and Appendix R calculations. In addition, ISCOR/TGBLA/PANAC code combinations are also used in core and fuel performance calculations.

a. ISCOR is widely used in many of the safety analyses, but the code was never reviewed by the NRC. The use of a non-NRC-approved code in a combined code system applications is problematic. Therefore, submit the ISCOR code for NRC review.

b. Although ISCOR is not an NRC-approved code, our audit review did not reveal specific shortcomings. [[

   ]] Therefore, include in the ISCOR submittal a description and evaluation of the ISCOR/ODYN or ISCOR/TGBLA/PANAC code combination discussed above. Provide sufficient information in the submittal, including sensitivity analyses, to allow the staff to assess the adequacy of these combined applications.

c. During the MELLLA+ audit , the staff discovered that GENE had internally evaluated a potential non-conservatism that may result from the use of the flow-driven ISOR/ODYN/TASC combination to calculate the transient ΔCPR. [[

   ]]

GE Response

Response to part a.

ISCOR calculates the flow distribution between the fuel channels and the bypass region for a given total core flow. The calculation of the flow distribution is based on a balancing of the pressure drop between the different channels; the flow is distributed such that all channels all have the same pressure drop. The thermal hydraulic model for the pressure drop is described in Section 4.2 of GESTAR II (Reference 1) and further details are contained in the response to request for additional information on Section 4 – Steady State Hydraulic Analyses in Appendix B of GESTAT II US Supplement (Reference 2). The response to the RAI describes the process for the calculation of the hot bundle flow. Further details on the model are provided in Section 4 of reference 3. All of these documents are NRC approved documents.

The hot channel response is calculated by TASC (Reference 4), which is an NRC approved report and describes the use of ISCOR to calculate the hot channel flow for TASC (see Figure 1-1 in Reference 4).

This methodology of using ISCOR in the transient methodology to provide input for the single channel analysis from the core average response has been used in both the GENISIS as well as the GEMINI methodologies. References 5-7 contain the qualification of the combined process starting with the calculation of the system response and ending with the calculation of the hot channel transient CPR response. References 5-7 are NRC approved documents.

GE considers the ISCOR methodology approved based on references 1-7. There is therefore no need to submit ISCOR for NRC review.

<u>Response to part b.</u>
See the response to 10.a.

<u>Response to part c.</u>

i. <u>Describe the issues identified in the PRC</u>
The PRC 91-01 issue was identified as follows:
"For some of the GE performed transient analyses, output of the system response code ODYN is used as input to the GETAB/TASC codes to calculate the transient change in MCPR for the hot bundle. This result is then combined with the Safety Limit MCPR and may be used to determine the operating limit MCPR. Currently, the ODYN calculated core flow is used as an input; a GETAB/TASC (ISCORE) determines the flow/pressure drop and transient Critical Power Ratio (CPR) for the hot bundle. Another approach is to assume that the ODYN calculated core pressure drop is the same for all fuel bundles, and have GETAB/TASC calculate the flow and CPR change for the hot bundle. Apparently, previous studies indicated that there was little difference in the results of the two approaches. However, some recent scoping studies have indicated that for some plants, some transients, and some critical power correlations, the latter approach results in higher calculated transient CPR changes that could result in calculationally exceeding the Safety Limit MCPR"

ii. <u>Explain if an alternative approach was proposed in the PRC</u>
The design basis NRC approved method is the ODYN flow driven method. The alternative approach is the ODYN pressure drop driven method. When GE reviewed the complete ODYN/TASC process, it was evident that the ODYN prediction of pressure drop had a strong influence on the result and there was a concern that the flow driven method may not be adequately conservative.

iii. <u>Explain why it was concluded that the alternative approach was not technically acceptable</u>

The conclusion was that the existing NRC approved ODYN flow driven method is technically acceptable. The alternate ODYN pressure driven method is more conservative, but since the existing approved method is acceptable, it is not necessary to change to the ODYN pressure driven method. Since TRACG is the most complete model, it was utilized to determine the overall accuracy of the approved ODYN/GETAB/TASC (ISCOR) flow driven method. The resulting design transient ΔCPR was found to be conservative relative to TRACG. The ODYN/GETAB/TASC (ISCOR) flow driven method was (and still is) considered the NRC approved method. Had the TRACG analysis not shown that the approved ODYN flow driven method was adequate, GE would have informed the NRC of their desire to change to the more conservative ODYN pressure driven method.

iv. <u>Explain the bases for closing the PRC</u>
The PRC 91-01 evaluation determined that the current flow driven method is acceptable. Best estimate calculations for limiting transients showed that the ΔCPR using the current NRC approved analysis procedure provides acceptably conservative results. Therefore, it was concluded that this issue did not represent a Reportable Condition under of 10CFR Part 21.

v. <u>Justify why the NRC was not informed, considering that a non-NRC approved codes were being used to both evaluate the identified non-conservatism (TRACG) and correct the ODYN 1-D hot bundle flow deficiencies (ISCOR)</u>
The NRC is informed when there is a reportable condition, 60 Day Interim Notification, or when a GENE PRC evaluation relates to an industry identified issue. The NRC is not normally informed of issues evaluated by GENE when it is concluded that it is not reportable or a Part 21 Transfer of Information is issued because GENE does not have the necessary information to complete the evaluation. In some cases, GENE may use more realistic, though still conservative methods to perform a PRC evaluation. For this case, that included using a non-NRC approved code to examine the adequacy of the simpler ODYN method to assess a potential non-conservative aspect of the approved procedure. Use of more realistic methods in a GENE internal PRC evaluation does not change the criteria by which an issue is reported to the NRC, i.e., it is reported only when it has been determined to be a reportable condition, the evaluation cannot be completed in 60 days, or it relates to an industry identified issue.

<u>References</u>

1. General Electric Standard Application for Reactor Fuel, GESTAR II, NEDE–24011–P–A–14, June 2000.
2. General Electric Standard Application for Reactor Fuel (Supplement for United States), NEDE–24011–P–A–14-US, June 2000.
3. Steady State Nuclear Methods, NEDE-30130-P-A, April 1985.
4. TASC-03A Computer Program for Transient Analysis of a Single Channel, NEDC-32084P-A, July, 2002.
5. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors. NEDO-24154-A, Volume I, August 1986.

6. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors. NEDO-24154-A, Volume II, August 1986
7. Qualification of the One-Dimensional Core Transient Model for Boiling Water Reactors. NEDE-24154-P-A, Volume III, August 1988

NRC RAI 11, Plutonium Buildup

It is expected that a EPU/MELLLA+ core would produce more Pu(239). What are the consequences of this increase from a neutronic and thermal-hydraulic standpoint during steady-state, transient, and accident conditions?

GE Response

The core simulator will properly capture any resulting increase of plutonium from high void operation. Additionally, the cycle specific transient analyses consider variation on the burn strategy and Pu production by varying the degree at which the bottom of the core is burned early in the cycle. Therefore, any changes in isotopic inventory because of MELLLA+ operation will be explicitly modeled for the purposes of determining cycle specific analyses including selection of rod patterns, safety evaluations (SDM), transient evaluations, as well as others.

NRC RAI 12, Spectrum Hardening
How does the harder spectrum from the increased Pu affect surrounding core components such as the shroud, vessel, and steam dryer?

GE Response
The hardening of neutron spectrum from the increased Pu mainly affects the thermal and epi-thermal energy regions and has insignificant effect on fast neutrons with energy greater than 1 MeV. Since the damage effect of neutron irradiation on the surrounding core components such as the shroud, vessel, and steam dryer is based on fast neutron (E > 1 MeV) fluence, the increased Pu does not have significant effect on the surrounding core components. [[

]] The increased void fraction does affect the flux distribution near the top of the core and beyond. The extent of impact could vary from plant to plant and requires plant specific evaluation. [[

]]

NRC RAI 13

How do the thermal margins change as a function of flow and transients for a EPU/MELLLA+ cores?

GE Response

The only EPU/MELLLA+ core is Brunswick-1 Cycle 15. The $\Delta CPR/ICPR$ is determined with TRACG. The following table provides $\Delta CPR/ICPR$ as a function of power and flow.

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			]]

<u>NRC RAI 14</u>
Demonstrate that the rod withdraw error (RWE) for the EPU/MELLLA+ domain is less limiting than the non-MELLLA+ domain throughout the cycle.

<u>GE Response</u>
[[

]] The following are the results of this study:

[[		
		]]

The following is a similar study for Brunswick-1 Cycle 15 at MELLLA+. The following are the results of this study:

[[		
		]]

[[ ]]

NRC RAI 15

If the axial power profile is expected to be more pronounced (more limiting) for a EPU/MELLLA+ core, demonstrate and provide a quantitative and qualitative technical justification of the effects of these more pronounced profiles on the normal and transient behavior of the core.

GE Response

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NRC RAI 16, Reload Analyses

Since the startup and intermediate rod patterns are developed by the licensees and subject to change during plant maneuvers, explain how you ensure that the core and fuel assessment analyses performed during the reload are still applicable. For example, if the safety limit for minimum critical power (SLMCPR) is performed at different burnup conditions during the cycle, how do you ensure that the plant's operating history does not invalidate the reload assumptions? How are the corrections or adjustments made to the plant's core and fuel performance analyses to ensure the parameters and conditions assumed during the reload analyses remain applicable during the operation. The staff's concern stems from the additional challenges that EPU/MELLLA+ pose in terms of core and fuel performance.

GE Response

The reload licensing analysis is based on a reference core loading which is documented in the Supplemental Reload Licensing Report (SRLR) for the plant and cycle being licensed. Deviations to this licensed reference core loading are allowed under the criteria defined in Section 3.4 of GESTAR II. Any variations in the core loading outside of these allowable deviations must undergo a re-examination as spelled out in that same section of GESTAR II. This re-examination can result in up to a complete relicense analysis if necessary.

The reload license analysis is also based on an assumed operational trajectory or set of design rod patterns. These design rod patterns represent a relatively detailed simulation of core operation at rated power using an operational philosophy that incorporates any utility instructions (regarding how they intend to operate), that optimizes core performance in regards to energy capability, thermal margins, operational simplicity and that meets all design and licensing requirements. The key nuclear reactivity assessments for reload licensing [strong-rod-out (SRO) shutdown margin and standby liquid control system (SLCS) shutdown margin as specified in Section 3.2 of GESTAR II] are analyzed both at beginning of cycle (BOC) and at selected exposure points through the cycle in enough detail to assure the maximum reactivity point during the cycle has been determined and that it meets the specified licensing criteria. To assure that the analysis will cover operational uncertainties in the previous cycle shutdown, these reactivity analyses are performed assuming a minimum energy accumulation scenario for the previous cycle. This previous cycle minimum energy requirement is also documented in the SRLR. Typically this previous cycle energy assumption has a stronger effect on the cold reactivity calculations (because it results in the carryover of additional reactivity on all of the exposed fuel) than variation in operational rod patterns. This is especially true for the SLCS analysis which is a core-wide reactivity event, not particularly sensitive to changes in local reactivity, and which most often exhibits minimum margin at BOC. For the SRO shutdown margin analysis a BOC demonstration is required of the plant and this demonstration is performed on the actual as-loaded core conditions.

The end of cycle (EOC) pressurization transients from which the core delta critical power ratio (ΔCPR) and ultimately the core minimum critical power ratio operating limit (OLMCPR) are derived are based on two operational trajectories which bound the expected or nominal operational trajectory (based on the design rod patterns discussed above). One of the bounding trajectories assumes the core operates through the cycle with a power shape substantially more bottom peaked than the expected axial power shape. This method of generating the bounding EOC condition is referred to as a hard bottom burn (HBB). This produces a more top peaked power shape at EOC and this more top peaked power shape in turn results in degraded scram reactivity performance relative to the expected EOC condition. Similarly, a second bounding trajectory assumes the core operates through the cycle with a power shape substantially more top peaked than the expected axial power shape. This produces a more bottom peaked power shape at EOC and is referred to as an under-burn (UB). The EOC pressurization transients are analyzed for both the HBB and the UB bounding power shape assumptions, and the limiting ΔCPR responses from both sets of analysis are used in establishing the OLMCPR. This provides assurance that reasonable operational variations on either side of the nominal projection are covered by the EOC transient analyses.

The statistical limit minimum critical power ratio (SLMCPR) analysis is performed under procedures and criteria approved by the NRC. In the SLMCPR analysis limiting rod patterns are established at multiple exposure points during the cycle so as to adequately characterize the core behavior. The limiting rod pattern criteria is constructed to achieve a core state at each of the exposure points that represents a limiting condition for establishing the SLMCPR. The object of the limiting rod pattern is to place a substantial fraction of the high power, interior bundles near the MCPR limit and then perform statistical analysis to determine the SLMCPR value at which 0.1% of the fuel rods would become susceptible to boiling transition. The object of achieving a relatively flat, near-limits core condition with the limiting rod pattern is to place a higher percentage of fuel bundles (and thus fuel rods) closer to this boiling transition threshold; enabling the 0.1% criteria to be reached at a higher SLMCPR. The statistical analysis for determining the SLMCPR is performed at all exposure points and the most limiting of these values is used to establish the SLMCPR for the plant/cycle.

NRC RAI 17, Thermal Limits Assessment

a. SLMCPR. It is possible that the impact on the critical heat flux (CHF) phenomena may be higher at the offrated or minimum core flow statepoints. Is the SLMCPR value provided in the SLMCPR amendment requests and reported in the TS based on the rated conditions? If so, justify why the SLMCPR is not calculated for statepoints other than the rated conditions. Quantitatively demonstrate that the SLMCPR calculated at the minimum 80 percent and 55 percent statepoints would be lower than the SLMCPR calculated at the rated conditions. Use power profiles and core designs that are representative of the EPU/MELLLA+ conditions. Discuss the assumptions made. Include the Brunswick EPU/MELLLA+ application in your sensitivity analyses.

b. SLMCPR at EPU/MELLLA+ Upper Boundary. The SLMCPR at the nonrated conditions (EPU power/80 percent CF) could be potentially higher than the SLMCPR at rated conditions, explain how "statepoint-dependent" SLMCPR would be developed and implemented for operation at the EPU/MELLLA+ condition. Use the Brunswick EPU/MELLLA+ application to demonstrate the implementation of "statepoint-dependent" SLMCPR.

c. Exposure-Dependent SLMCPR. Discuss the development of the exposure-dependent SLMCPR calculation. State whether this is an NRC-approved method and refer to the applicable GESTAR II amendment request.

GE Response

a. The SLMCPR is a particular critical power ratio (CPR). The mechanism for transition boiling due to a CPR value approaching 1.0 is a film dryout mechanism that depends on integrated power. This mechanism is different from the localized critical heat flux (CHF) phenomena for boiling transition that is relevant for PWRs.

   The calculated SLMCPR is based on the highest licensed power and flow conditions. This approach has been shown in NEDC-32601P-A to produce SLMCPR values that are slightly conservative (note in particular Figure II.4-1 on page B-5.) Whereas it is true that the CPRs are sensitive to flow and decrease as the flow decreases, the SLMCPR is sensitive to the relative distribution of the CPRs not their absolute values. The relative distribution of CPRs in the core does not change appreciably with flow changes in the operating domains where the power is high enough for CPRs to be a concern. Rather, the SLMCPR is dominated by the uncertainty in CPRs as a result of the uncertainties in the two dominant inputs: power and flow. As the core flow decreases, its absolute uncertainty remains essentially unchanged because it is dominated by the uncertainty in the pressure drop which in turn is dominated by the uncertainty in the ability to measure pressure drops which does not depend on the magnitude of the flow. This fact alone suggests that the calculated SLMCPRs will be insensitive to a reduction in flow. In fact, due to a slight flattening of the relationship between critical power and flow at the higher flows, the CPR distributions in the core tend to be slightly flatter at the higher flows so the calculated SLMCPR will increase very slightly for the higher flows (as shown in Figure II.4-1 on page B-5 of NEDC-32601P-A).

Power is the more important factor. The power uncertainties are proportional to the absolute power so the greater uncertainty and the more conservative SLMCPR values occur at the higher powers. This means that the SLMCPR should be calculated at the highest licensed power and flow. This is the reason that SLMCPR values for single-loop operations (SLO) are conservatively calculated using the higher flow uncertainties associated with SLO but at the highest licensed power and flow conditions even though those conditions obviously are not achievable for SLO.

The core loading and the bundle design strongly influence the SLMCPR. Both of these are accounted for by performing cycle-specific analyses of the as-built bundles and the reference core loading. The bundle must be designed and the core loaded to support MELLLA+ operation. From the perspective of CPR performance this means that the bundles must have a very flat critical power response over a wide range of flows. Such designs produce an even smaller uncertainty in CPR due to perturbations in flow than do bundles not designed for MELLLA+ operation. In either case, these uncertainties are accounted for in determining the GEXL uncertainty determined for use in the SLMCPR calculation. Obviously, the GEXL development must and does cover the range of intended operations in terms of power, flow, power shape, pressure, etc.

MELLLA+ operations that use reduced flow to harden the neutron spectrum in order to build-in plutonium and extend cycle operation will have two competing effects on bundle design. (1) Rod peaking factors must be maintained low enough that CPR performance can still be achieved at high powers and lower flows, e.g., the bundle designs need to be flattened. (2) Rod enrichments need to be high enough to achieve the desired cycle exposures and maintain sufficient reactivity to offset the negative impact of higher core voiding at the reduced flows, e.g., the bundle peakings are increased to accommodate more enrichment and the associated increases in gadolinium loaded to control the reactivity. All these effects are accounted for in the present cycle-specific SLMCPR methodology that evaluates the actual bundle designs to be loaded. Generally speaking, bundle designs for MELLLA+ operations will tend to go in the same direction as for extended power uprates (EPU) and longer-exposure cycles, namely in the direction of being slightly more peaked which means that calculated SLMCPRs will continue to trend downward (not upward). The competing design constraints for MELLLA+ result in bundles whose R-factor distributions are approximately in the middle of the distributions that are regularly analyzed during SLMCPR evaluations.

The other important design aspect is the core loading. Higher energy requires lower radial peaking factors. In other words, each bundle must be closer in power to the average bundle power so that either the average power per bundle can increase as is the case for EPU or the flow can be reduced for the same bundle power as is the case for MELLLA+. Both scenarios result in a flatter MCPR distribution in the as-loaded core. If this were the only constraint, one would expect that calculated SLMCPR values would be increasing whereas, in fact, they are not. That is because higher energies also require higher batch fractions which mean that these batches must consist of mixed streams of different bundle designs in order to control reactivity during the cycle and minimize enrichment costs. Thus, the number and distribution of MCPRs for the highest power bundles in the design that set the SLMCPR for the core remain approximately constant. The absolute power needed to drive the MCPR in these bundles down to the SLMCPR during a postulated AOO event remains unchanged since this power depends only on the critical power capability of the bundle. The fact that these limiting bundles may start at a lower MCPR because of reduced flow (or higher power) is relevant for the assessment of the operating limit MCPR (OLMCPR), but is not relevant for the SLMCPR which depends only on the relative distributions of these MCPRs. The OLMCPR is determined by the transient change in CPR for such postulated events such as a turbine trip without bypass can actually be lower because of the lower radial peaking factors for these core designs. Both the SLMCPR and the OLMCPRs for different scenarios are determined on a cycle-specific basis considering the actual bundle designs and the reference loading pattern. Again the key point with respect to the SLMCPR is that these considerations are no different from those that are already considered as part of the cycle-specific SLMCPR evaluations.

The key assumption for the Brunswick EPU/MELLLA+ application as it pertains to the SLMCPR evaluation is that the actual bundle designs and the reference loading pattern will be used to perform the analyses that establish the Technical Specification SLMCPR. This is in fact a procedural requirement. These calculations will be performed at the highest licensed values for core power and core flow as is the case for all other cycle-specific SLMCPR calculations.

b. The SLMCPR is not intended to be used as a "state-point-dependent" quantity. Use of the TRACG AOO methodology (NEDE-32906P-A) decouples the OLMCPR(s) from the SLMCPR. OLMCPR(s) can be "state-point-dependent" using a single SLMCPR for the cycle or SLMCPR as a function of exposure. (See Response 17(c)).

   There is no basis for the premise that the "SLMCPR at the non rated conditions (EPU power/80 percent CF) could be potentially higher than the SLMCPR at rated conditions". This subject is addressed in Response 17.a.

c. Exposure-dependent SLMCPR values were introduced in Amendment 25 to GESTAR II that was submitted for NRC review and approval in December 1996. The NRC SER approving this approach was issued March 11, 1999. The exposure-dependent SLMCPR calculations complement the introduction of the cycle-specific methodology. Since the introduction of the cycle-specific methodology, SLMCPR values typically have been calculated at different exposure points during a cycle and the highest value through the cycle determines the minimum value that can be used for the Technical Specification SLMCPR for that cycle; however, Revision 14 of GESTAR II and later revisions specifically allow the SLMCPR values to be stipulated as a function of exposure. If used, the exposure-dependent SLMCPR values are calculated at discrete points during the cycle using the NRC-approved methods documented in NEDC-32601P-A and NEDC-32694P-A. A table of these calculated values versus cycle exposure are then provided in a revision to the plant Technical Specifications.

NRC RAI 18, GEXL-PLUS Correlation

Confirm that the GEXL-PLUS correlation is still valid over the range of power and flow conditions of the EPU/MELLLA+ operations.

GE Response

See the response to RAI 6(e) for justification of adequacy of the GEXL+ correlation for MELLLA+ conditions

NRC RAI 19, Using ATWS-Recirculation Pump Trip (RPT) for AOOs

GENE licensing methodology allows using anticipatory ATWS-RPT in some AOO transients to decrease the power and pressure response. Therefore, the anticipatory RPT is used in some plants to minimize the impact of the pressurization transient on the ΔCPR response. For the EPU MELLLA+ operation, RPT may subject the plant to instability. Evaluate the runbacks associated with the AOOs and demonstrate that the scram and the RPT timings would not lead to an AOO transient resulting in an instability.

GE Response

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NRC RAI 20, Mechanical Overpower (MOP) and Thermal Overpower (TOP)

Are the fuel-specific mechanical and thermal overpower limits determined based on the generic fuel design or for each plant-specific bundle lattice design? How is it confirmed that the generic MOP and TOP limits for GE14 fuel bounds the plant-specific GE14 lattice designs intended to meet the cycle energy needs at the EPU/MELLLA+ conditions?

GE Response

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<u>NRC RAI 21, Brunswick AOO</u>

The Brunswick Units 1 and 2 are the first plants to apply TRACG for performing the reload analyses.

a. Compare the Brunswick EPU and the EPU/MELLLA+ core designs and performance.

b. State what is the benefit of using TRACG instead of ODYN for the EPU/MELLLA+ reload analyses.

c. Provide a comparison of the TRACG and ODYN AOO analyses results based on the EPU/MELLLA+ core design.

<u>GE Response</u>

a. [[ ]]

b. [[ ]]

c. Figures AOO-21-1 through AOO-21-5 provides the comparison

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Figure AOO-21-1. TRACG vs ODYN Neutron Flux TTNB Event at M+

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Figure AOO-21-2. TRACG vs ODYN Core Flow TTNB Event at M+

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Figure AOO-21-3. TRACG vs ODYN Vessel Stream Flow TTNB Event at M+

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Figure AOO-21-4. TRACG vs ODYN Vessel Pressure TTNB Event at M+

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Figure AOO-21-5. TRACG vs ODYN SRV Flow TTNB Event at M+

NRC RAI 22, Brunswick AOO Data Request

Submit the following data on compact disc for the Brunswick EPU/MELLLA+ core and fuel performance analyses.

a. TRACG input file including the PANCEA wrap file for a limiting transient initiated from different statepoints along the EPU/MELLLA+ boundary, if available. Include the corresponding output file in ASCI form.

b. ODYN output file (ASCI) for the same transients and statepoints.

GE Response

The requested information was provided in Enclosure 4 of GE letter dated February 27, 2004 (MFN 04-020).

NRC RAI 23, Separate Effects, Mixed Vendor Cores and Related Staff Restrictions
Separate effects: revise Section 1.0, "Introduction," of the MELLLA+ LTR and remove the list of "separate effects" changes. The MELLLA+ LTR lists plant-specific operating condition changes that could be implemented concurrently with the EPU/MELLLA+, but would be evaluated in a separate submittal. All of these lists of changes would affect the safety analyses that demonstrate the impact of EPU/MELLLA+ on the plant's response during steady-state, transients, accidents, and special events. The plant-specific EPU/MELLLA+ application must demonstrate how the plant would be operated during the implementation of MELLLA+. In addition, the EPU/MELLLA+ reduces the available plant margins. Therefore, the staff cannot make its safety finding based on assumed plant operating conditions that are neither bounding nor conservative relative to the actual plant operating conditions. Revise the MELLLA+ LTR and delete the paragraphs that propose evaluating additional operating condition changes in a separate submittal while the EPU/MELLLA+ application assumes that these changes would not be implemented.

Add the following statements in the MELLLA+ LTR to address staff restrictions including: (1) the implementation of additional changes concurrent with EPU/MELLLA+, (2) the applicability of the generic analyses supporting the EPU/MELLLA+ operation, and (3) the approach used to support new fuel designs or mixed vendor cores.

a. The plant-specific analyses supporting the EPU/MELLLA+ operation will include all planned operating condition changes that would be implemented at the plant. Operating condition changes include but are not limited to increase in the dome pressure, maximum core flow, increase in the fuel cycle length, or any changes in the currently licensed operation enhancements. For example, with increase in the dome pressure, the ATWS analysis, the American Society of Mechanical Engineers (ASME) overpressure analyses, the transient analyses, and the ECCS-LOCA analysis must be reanalyzed based on the increased dome pressure. Any changes to the safety system settings or actuation setpoint changes necessary to operate with the increased dome pressure should be included in the evaluations (e.g., safety relief valve setpoints).

b. For all of the principal topics that are reduced in scope or generically dispositioned in the MELLLA+ LTR, the plant-specific application will provide supporting analyses and evaluations that demonstrate the cumulative effect of EPU/MELLLA+ and any additional changes planned to be implemented at the plant. For example, if the dome pressure would be increased, the ECCS performance needs to be evaluated on a plant-specific basis.

c. Any generic sensitivity analyses provide in the MELLLA+ LTR will be evaluated to ensure that the key input parameters and assumptions used are still applicable and bounding. If the additional operating condition changes affects these generic sensitivity analyses, a bounding generic sensitivity analyses will be provided. For example, with increase in the dome pressure, the TRACG ATWS sensitivity analyses that model the operator actions (e.g., depressurization if the heat capacity temperature limit is reached) needs to be reanalyzed, using the bounding dome pressure condition.

d. If a new GE fuel or another vendor's fuel is loaded at the plant, the generic sensitivity analyses supporting the EPU/MELLLA+ condition will be reanalyzed. For example, the ATWS instability analyses supporting the EPU/MELLLA+ condition are based on the GE14 fuel response. New analyses that demonstrate the ATWS stability performance of the new GE fuel or legacy fuel for the EPU/MELLLA+ operation needs to be provided. The new ATWS instability analyses can be provided as supplement to the MLTR or as an Appendix to the plant-specific application.

e. If a new GE fuel or another vendor's fuel is loaded at the plant, analyses supporting the EPU/MELLLA+ application will be based on core specific configuration or bounding core conditions. In addition, any principle topics that are generically dispositioned or reduced in scope will be demonstrated to be applicable or new analyses based on the transition core conditions or bounding conditions would be provided.

f. If a new GE fuel or another vendor's fuel is loaded at the plant, the plant-specific application will reference the fuel-specific stability detect and suppress method supporting the EPU/MELLLA+ operation. The plant-specific application will demonstrate that the analyses and evaluation supporting the stability detect and suppress method are applicable to the fuel loaded in the core.

g. For EPU/MELLLA+ operation, instability is possible in the event of transient or plant maneuvers that place the reactor at high power/low flow condition. Therefore, plants operating at the EPU/MELLLA+ condition must have an NRC reviewed and approved instability detect and suppress method operable. In the event the stability protection method is inoperable, the applicant must employ NRC reviewed and approved backup stability method or must operate the reactor at a condition in which instability is not possible in the event of transient. The licensee will provide technical specification changes that specify the instability method operability requirements for EPU/MELLLA+ operation.

GE Response

Per the RAI request, Section 1 of the MELLLA+ LTR will be modified as shown below. Portions of the suggested content of the RAI have been changed to provide consistency with the MELLLA+ LTR and implementation process. For example, each instance of EPU/MELLLA+ contained in the suggested content of the RAI has been changed to MELLLA+. The MELLLA+ LTR is supported by analyses at power levels up to 120% OLTP. However, the LTR is based on the premise that there is no change in power level with the MELLLA+ application. Therefore, the power level for a plant specific application will be the plant's CLTP, which may not be at the 120% OLTP (EPU) power level.

1.0 Introduction

Power uprates in GE Boiling Water Reactors (BWRs) of up to 120% of original licensed thermal power (OLTP) have been based on the guidelines and approach provided in References 1 and 2 (ELTR1 and ELTR2). A number of extended power uprate (EPU) submittals have been based on these reports. The approach in ELTR1 and ELTR2 allows an increase in the maximum operating reactor pressure, when the reactor power is uprated. Subsequent to the approval of ELTR1 and ELTR2, GE developed an approach to uprate reactor power while maintaining the current reactor maximum operating reactor vessel dome pressure. The power uprate option with no dome pressure increase has been used at several plants, and is expected to be used for most future uprate applications. An improved approach for a Constant Pressure Power Uprate (CPPU) has been submitted in Reference 3 (CLTR).

This Licensing Topical Report (LTR) defines the approach and provides the basis for an expansion of the operating range for plants that have uprated power, either with or without a change in the operating pressure. This core flow rate operating range expansion does not change the current plant vessel dome operating pressure. The improvement in the operating range is identified as Maximum Extended Load Line Limit Analysis Plus (MELLLA+). The current Maximum Extended Load Line Limit Analysis (MELLLA) operating range is characterized by the operating statepoint of reactor thermal power of 100% of OLTP at 75% of rated core flow. Some plants currently combine the MELLLA operating region with Increased Core Flow (ICF) resulting in an operating map called Maximum Extended Operating Domain (MEOD). Uprating to 120% OLTP using the MELLLA or MEOD boundary, restricts the core flow to 99% of rated at full power operation. This results in a reduced core flow range available for flexible operation at the uprated power. [[

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The following limitations and restrictions must be addressed by Licensees referencing this LTR to obtain a license for a MELLLA+ operating range expansion.

1. The plant-specific analyses supporting MELLLA+ operation will include all operating condition changes that are implemented at the plant at the time of MELLLA+ implementation. Operating condition changes include, but are not limited to, an increase in the dome pressure, maximum core flow, or fuel cycle length, or any changes in the licensed operational enhancements. For example, with an increase in dome pressure, the ATWS analysis, the American Society of Mechanical Engineers (ASME) overpressure analyses, the transient analyses, and the ECCS-LOCA analysis will be reanalyzed based on the increased dome pressure. Any changes to the safety system settings or actuation setpoint changes necessary to operate with the increased dome pressure will be included in the evaluations (e.g., safety relief valve setpoints).

   This restriction does not apply to modifications that may be licensed and implemented following MELLLA+ implementation.

2. For all topics in the MELLLA+ LTR that are reduced in scope or generically dispositioned, the plant-specific application will provide justification that the reduced scope or generic disposition is applicable to the plant.

   If changes that invalidate the LTR dispositions are to be implemented at the time of MELLLA+ implementation, the plant-specific application will provide analyses and evaluations that demonstrate the cumulative effect with MELLLA+. For example, if the dome pressure is increased, the ECCS performance will be evaluated on a plant-specific basis.

3. Any generic bounding sensitivity analyses provided in the MELLLA+ LTR will be evaluated to ensure that the key plant specific input parameters and assumptions are applicable and bounded. If these generic sensitivity analyses are not applicable or additional operating condition changes affect the generic sensitivity analyses, a plant-specific evaluation will be provided. For example, with an increase in the dome pressure, the ATWS sensitivity analyses that model the operator actions (e.g., depressurization if the heat capacity temperature limit is reached) needs to be reanalyzed, using the bounding dome pressure condition.

4. If a new GE fuel product line or another vendor's fuel is loaded at the plant, the applicability of any generic sensitivity analyses supporting the MELLLA+ application will be justified in the plant-specific application. If the generic sensitivity analyses cannot be demonstrated to be applicable, the analyses will be performed including the new fuel. For example, the ATWS instability analyses supporting the MELLLA+ condition are based on the GE14 fuel response. New analyses that demonstrate the ATWS instability performance of the new GE fuel or other vendor's fuel for MELLLA+ operation will be provided to support the plant-specific application.

5. If a new GE fuel product line or another vendor's fuel is loaded at the plant prior to a MELLLA+ application, the analyses supporting the plant-specific MELLLA+ application will be based on a specific core configuration or bounding core conditions. Any topics that are generically dispositioned or reduced in scope in the MELLLA+ LTR will be demonstrated to be applicable, or new analyses based on the specific core configuration or bounding core conditions will be provided.

6. If a new GE fuel product line or another vendor's fuel is loaded at the plant prior to a MELLLA+ application, the plant-specific application will reference an NRC approved stability method supporting MELLLA+ operation, or provide sufficient plant-specific information to allow the NRC to review and approve the stability method supporting MELLLA+ operation. The plant-specific application will demonstrate that the analyses and evaluations supporting the stability method are applicable to the fuel loaded in the core.

7. For MELLLA+ operation, a core instability is possible in the event a transient or plant maneuver places the reactor at a high power/low flow condition. Therefore, plants operating at MELLLA+ conditions must have an NRC reviewed and approved instability

protection method. In the event the instability protection method is inoperable, the applicant must employ an NRC reviewed and approved backup instability method. The licensee will provide technical specification changes that specify the instability method operability requirements for MELLLA+ operation, including any backup stability protection methods.

The effects of the MELLLA+ operating range expansion on plant safety evaluations and system assessments are addressed in this LTR. Many systems and evaluations that are part of a power uprate may be dispositioned as unaffected by the MELLLA+ changes. For example, the portions of the plant involved in power generation and electrical distribution experience no changes due to the introduction of the MELLLA+ operating range for the reactor.

<u>NRC RAI 24, Reactor Safety Performance Evaluations</u>

From the AOO audit, the staff determined that (1) GENE did not provide statistically adequate sensitivity studies that demonstrate the impact of EPU/MELLLA+ operation, [[

]] (3) the generic anticipatory reactor trip system (ARTS) response may not be applicable for all BWR applications, and (4) the EPU/MELLLA+ impact was not insignificant. The staff also finds that it is not acceptable to makes safety findings on two major changes (20 percent uprate based on the CPPU approach and MELLLA+) without reviewing the plant-specific results. [[

]] EPU/MELLLA+ applications must provide plant-specific fuel thermal margin and AOO evaluations and results. The following discussion summarizes the staff's bases for concluding that the plant-specific EPU/MELLLA+ application must provide a plant-specific thermal limits assessment and plant-specific transient analyses results.

a. <u>EPU/MELLLA+ Core Design</u>. Operation in the MELLLA+ domain will require significant changes to the BWR core design. Expected changes include (1) adjustments to the pin-wise enrichment distribution to flatten the local power distribution, reduce the r-factor, and increase CPR margin; (2) increased gadolinium (Gd) loading in the bottom of the fuel bundle to reduce the axial power peaking resulting from increased coolant voiding, and (3) changes in the core depletion due to the sequential rod withdrawal/flow increase maneuvers expected during operation in the MELLLA+ flow window. [[

   ]] However, the model used for these AOO calculations is not based on a MELLLA+ core, which has been designed for reduced flow at uprated power. Therefore, none of the sensitivity analyses supporting MELLLA+ operation have been performed for a core which includes the unique features of a MELLLA+ core design. Consequently, the effect of MELLLA+ on AOO ΔCPR has not been adequately quantified.

b. <u>Reload-Specific Evaluation of the AOO Fuel Thermal Margin</u>. [[

   ]] The available data is also limited.

c. <u>Offrated Limits</u>. The staff determined that the offrated limits (including along the MELLLA+ upper boundary) ΔCPR response may be more limiting than transients initiated from rated conditions. Therefore, AOO results from EPU applications cannot be used as sufficient bases to justify not providing the core and fuel performance results for the plant-specific MELLLA+ applications. Moreover, it has not been demonstrated that the generic ARTS limits are applicable and will bound the plant and core-specific offrated transient response for all of the BWR fleet. Therefore, offrated transient analyses must be performed to demonstrate the plant's ΔCPR response.

d. Mixed Core. Many of the BWRs seeking to implement the EPU/MELLLA+ operating domain may have mixed vendor cores. GENE's limited (MELLLA+) sensitivity analyses were based on GE14 fuel response of two BWR plants. Additional supporting analyses and a larger MELLLA+ operating experience database will be required before generic conclusions can be reached about the impact of MELLLA+ on core and fuel performance. Specifically, there is no operating experience or corresponding database available for assessing the performance of mixed vendor cores designed for EPU/MELLLA+ operation. As such, plant-specific fuel and core performance results must be submitted until a sufficient operating experience and analyses data base is available. In addition, new fuel designs in the future may change the core and fuel performance for the operation at the EPU/MELLLA+ operation. Therefore, the staff's EPU/MELLLA+ safety finding must be based on plant-specific core and fuel performance.

e. For the CPPU applications, the core and fuel performance assessments are deferred to the reload. Therefore, MELLLA+ LTR proposes that the staff approve an EPU/MELLLA+ application without reviewing the plant's response for two major operating condition changes. This approach would not meet the agency's safety goals.

GE Response

The plant-specific EPU/MELLLA+ application will provide plant-specific thermal limits assessment and transient analyses results.

NRC RAI 25, Large Break ECCS-LOCA

a. Mixed Core. For a plant-specific EPU/MELLLA+ application, state if equilibrium ECCS-LOCA analyses of each type would be performed or core configuration specific ECCS-LOCA analyses would be performed. If a core configuration specific ECCS-LOCA analyses will be performed, state which NRC-approved codes or methods would be used.

b. Reporting Limiting ECCS-LOCA Results. The MELLLA+ audit indicated that the rated ECCS-LOCA results are reported although it may not be for the most limiting results. For the EPU/MELLLA+ operation, the most limiting ECCS-LOCA result is at the MELLLA+ statepoint of 55 percent CF. Revise the MELLLA+ LTR to state that the ECCS-LOCA result at rated condition, minimum core flow at EPU power level and at the 55 percent CF statepoint will be reported. In addition, revise the applicable documents that specify the GENE licensing methods to state that the ECCS-LOCA result corresponding to the rated and the most limiting statepoint will be provided. Report in the supplemental reload licensing report (SRLR), the ECCS-LOCA results at the rated and the most limiting statepoints. Confirm that the steady-state initial conditions (e.g., operating limit maximum critical power ratio [OLMCPR]) assumed in the ECCS-LOCA analyses will be reported in the SRLR.

c. Adder Approach. Was the licensing bases PCT calculated by incorporating a delta PCT adder to the Appendix K PCT? If this is the method used, please justify why the 10 CFR 50.44 insignificant change criteria is acceptable.

GE Response

a. The ECCS-LOCA analysis for EPU/MELLLA+ follows the approved SAFER/GESTR application methodology documented in NEDE-23785-1-PA Rev. 1, "The GESTR-LOCA and SAFER Models for the Evaluation of the Loss-Of-Coolant Accident Volume III, SAFER/GESTR Application Methodology," October 1984. [[

]] The analytical models used to perform ECCS-LOCA analyses are also documented in NEDE-23785-1-PA together with NEDE-30996P-A, "SAFER Model for Evaluation of Loss-of-Coolant Accidents for Jet Pump and Non-jet Pump Plants, Volume I, SAFER – Long Term Inventory Model for BWR Loss-of-Coolant Analysis," October 1987, and NEDC-32950P, "Compilation of Improvements to GENE's SAFERECCS-LOCA Evaluation Model," January 2000.

b. The justifications for the state point used for establishing the plant Licensing Basis PCT and the methodology for evaluating expanded operating domains are documented in Section 6 of NEDC-32950P, "Compilation of Improvements to GENE's SAFER ECCS-LOCA Evaluation Model," January 2000. As stated in the letter from S.A. Richards to J.F. Klapproth, "General Electric Nuclear Energy (GENE) Topical Reports GENE-32950P and GENE-32084P Acceptability Review," May 24, 2000, this report has been accepted as fulfilling the intent of the code change and error reporting requirements of 10 CFR 50.46. Conformance with the 10 CFR 50.46 acceptance criteria and the NRC SER requirements for application of the SAFER/GESTR-LOCA methodology is demonstrated for the MELLLA+ domain in the plant-specific MSAR submittal.

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c. The 10 CFR 50.46 (a)(3)(i) change criterion does not apply to the MELLLA+ evaluation because the MELLLA plus evaluation is not a change to an acceptable evaluation model or error. The MELLLA+ ECCS performance evaluation demonstrates that plant operation in the MELLLA+ power/flow region meet the 10CFR50.46 acceptance criteria and is in compliance with NRC requirements for the SAFER/GESTR application methodology. These results are reported to the NRC in the plant-specific MELLLA+ licensing submittal.

NRC RAI 26, Small Break ECCS-LOCA Response

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assuming high pressure coolant injection (HPCI) failure and automatic depressurization system depressurization. At the 55 percent CF statepoint (Point M), the hot bundle may be at a more limiting initial condition in terms of initial void content and the ADS would depressurize the reactor leading to core uncovery as well. Provide a sensitivity ECCS-LOCA analysis, using the bounding initial condition. Provide a small break LOCA analysis at point M (77.6 percent Power/55 percent CF), based on the bounding initial condition, worst case small break scenario and placing the hot bundle at the most limiting conditions (peaking factors). Use initial SLMCPR and OLMCPR condition that is bounding for operation at 80 percent CF or 55 percent CF statepoint.

GE Response

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NRC RAI 27, Small Break Containment Response

Using the most limiting small break LOCA, in terms of containment response (possibly at rated condition if limiting), demonstrate whether the suppression pool temperature response to a design basis accident is limiting. Wouldn't a small break LOCA (e.g., assuming HPCI failure and depressurization of the reactor) be more limiting in terms of suppression pool response? Base your evaluations on the Brunswick and Clinton applications.

GE Response

The peak suppression pool temperature for the small break accident (SBA) with vessel depressurization is not expected to exceed the peak suppression pool temperature for the DBA-LOCA. The key energy sources that affect the peak suppression pool temperature are the vessel decay energy and the initial vessel sensible energy.

The decay energy is determined by the decay power time-history and the initial power level. These parameters are the same for both events.

For a DBA-LOCA, the initial vessel sensible liquid energy is rapidly transferred to the suppression pool during the initial vessel blowdown period. The liquid break flow from the vessel during the blowdown period partially flashes in the drywell, resulting in a homogeneous mixture of steam and liquid in the drywell. This mixture is forced rapidly from the drywell, through the vent system, to the suppression pool. The vessel is depressurized to the ambient drywell pressure within a few minutes of the start of the event. This effectively transfers the initial vessel liquid sensible energy to the pool within minutes of the start of the event. [

]] After the vessel blowdown period, relatively cold ECCS liquid from the suppression pool enters the vessel. The ECCS flow floods the vessel to the break elevation and delivers a stream of liquid from the vessel to the drywell. [[

]] After vessel depressurization is completed for the SBA, decay energy continues to produce steam in the vessel. This decay energy is transferred to the suppression pool via intermittent SRV discharges to the suppression pool, which maintains the vessel at low pressure. This process produces a slow heat up of the suppression pool. As with the DBA-LOCA, the peak pool temperature occurs when the energy removal rate by the RHR system equals the energy addition rate to the suppression pool.

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Analysis Confirmation

To confirm the discussion provided above, the results of SBA containment analyses were compared to the results of DBA-LOCA containment analyses. Sensitivity analyses of the SBA event were performed for Brunswick with EPU conditions. SBA containment analyses were not available for the Clinton EPU application. However, the results of SBA analyses performed with EPU conditions for another, non-US, BWR/6-218 plant with a Mark III containment (similar to Clinton) were reviewed for the evaluation.

The Brunswick EPU SBA sensitivity analyses assumed HPCI failure and vessel depressurization. The analyses included cases where vessel depressurization with ADS was modeled and cases where manually controlled vessel depressurization was modeled. The peak suppression pool temperature obtained for the analysis with ADS modeled was 204.4°F. The peak suppression pool temperature with controlled vessel depressurization modeled was 206.9°F. In both cases the peak suppression pool temperatures were similar to but not higher than the peak suppression pool temperature obtained from the DBA-LOCA value of 207.7°F.

The SBA analysis performed for the BWR/6-218 plant assumed manually controlled vessel depressurization. The peak suppression pool temperature obtained from the SBA analysis was slightly higher than the peak DBA-LOCA suppression pool temperature but only by 0.8°F.

These results confirm that the SBA event does not produce more limiting conditions with respect to peak suppression pool temperature.

NRC RAI 28, Assumed Axial Power Profile for ECCS-LOCA

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]] Base your discussion on the predicted response in terms of dryout times. In addition, explain what the axial power peaking would be if the fuel is placed at the LHGR limit at rated conditions, 80 percent CF and 55 percent CF condition. If the axial power peaking would be higher for the non-rated flow conditions, state what axial power peaking were used in the ECCS-LOCA sensitivity analyses reported in MELLLA+ LTR for the 80 percent and 55 percent CF statepoints.

GE Response

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]] The table below shows the effect of the power / flow (P/F) and power profile on the dryout times of the peak power node of the hot bundle.

Dryout Times of Peak Power Node for Various P/F Conditions and Power Shape

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The axial peaking factors (APFs) in the table below are the factors needed to place the hot bundle on the PLHGR target when the bundle power places the bundle on the MCPR target. These APFs are much larger than would be expected to occur during plant operation. It is also unlikely that a top peak shape would be on the PLHGR target and MCPR target at the same time.

Axial Peaking Factors for Various P/F Conditions and Power Shape

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The effect of the power profile on the PCT is shown in the table below. The effect of the power profile on the PCT is small. The impact of the power profile is larger on 1st Peak PCT than on the limiting 2nd Peak PCTs. [[

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Appendix K PCTs for Various P/F Conditions and Power Shape

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The following table provides the axial peaking factors used in the analyses supporting the MELLLA+ LTR. The analyses supporting the LTR used a slightly different approach than the above analyses in setting the hot bundle on the MCPR target. In the above analyses, the limiting R-factor based on the specific fuel bundle type (GE14) is used and the bundle power is varied to place the bundle on the MCPR limits; this results in different radial and axial peaking factors for each case. Using a fixed limiting R-factor gives more representative trends.

In the analyses supporting the LTR, the bundle power is fixed at a value higher than expected during operation and the R-factor is varied to place the bundle on the MCPR target as long as it remains above a minimum value. If the minimum is reached, the bundle power is reduced to obtain the MCPR target. This approach results in the same peaking factors except at low core flow.

Axial Peaking Factors Used in the Analyses Supporting the LTR

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In conclusion, the dryout times of the peak power node for the mid-peaked profile are about the same or earlier than those of the top-peaked profile. [[

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NRC RAI 29, Power/Flow Map

The MELLLA+ LTR states that the slope of the linear upper boundary was derived primarily from reactor operating data. Expand on this statement. Explain what operating data was used. Were all plant types represented? Was the line developed as a bounding line or as a fit to the referred reactor operating data?

GE Response

One of the goals for the MELLLA+ project was to incorporate utility input as to the characteristics of the region to be used for the analyses. The general utility input was that the MELLLA+ upper boundary should be more representative of plant performance, in contrast to the MELLLA upper boundary bias toward a steep load line. Recent operating plant data from 4 BWRs with newer fuel designs was extrapolated to higher load lines to derive the analytical upper boundary for the MELLLA+ operating region. While a specific load line is influenced by some plant specific factors, such as feedwater temperature and core size, the variation of load line due to changing core characteristic factors, such as reactivity coefficients and power distribution, indicates that a few typical plants with different core characteristics will be representative. The resulting MELLLA+ upper boundary represents a nominal power to flow load line. The MELLLA+ upper boundary line represents the analyzed operating region and it is therefore a requirement for normal operation. The evaluations performed to justify operation in the MELLLA+ region assure that all operating condition within the MELLLA+ upper boundary are acceptable.

<u>NRC RAI 30, Power/Flow Map</u>

The MELLLA+ minimum statepoint for rated EPU power was limited to 80 percent CF. Explain what the limitations were in establishing the minimum core flow statepoint. Similarly, discuss the limitations considered in establishing the 55 percent core statepoint. Discuss why the feedwater heater out-of-service and single loop operation is also not allowed for the EPU/MELLLA+ operation.

<u>GE Response</u>

Both the minimum core flow of 80% of rated for 100% power and the minimum core flow of 55% of rated for the low boundary represent the practical limitations of normal BWR operation. [[

]] Thus the 80% of rated core flow was selected. [[

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(a) FWHOOS; The establishment of the MELLLA+ region included considerations of practical application, as well as limiting adverse consequences in plant safety analyses. [[

]] However, this feedwater temperature reduction would need to be evaluated on a plant specific basis and is not part of the standard MELLLA+ evaluation. Finally, it should also be noted that operation in FWHOOS is considered only a contingency option, for temporary feedwater heater equipment deficiency therefore, this limitation is not expected to impose a significant limitation to plant availability.

(b) SLO; The core flow attainable with a single recirculation pump is typically 50% of rated, and not expected to be higher than 60% of rated. Then it follows that since the MELLLA+ region is limited to a minimum flow of 55% of rated, it would be extremely difficult for a BWR to maneuver into the high power condition corresponding to the MELLLA+ region, where little flow margin for operation exists. Therefore, there is no incentive to operate in SLO at higher power in MELLLA+.