April 29, 2009

ORGANIZATION: GE Hitachi Nuclear Energy (GEH)

PROJECT: Economic Simplified Boiling Water Reactor (ESBWR) Design Certification

SUBJECT: ESBWR COMPUTER CODE REVIEW TECHNICAL SUMMARY INCLUDING A FOLLOWUP REVIEW SUMMARY FOR THE TRACG04 SAFETY ANALYSIS CODE

From December 15, through December 19, 2008, the U.S. Nuclear Regulatory Commission (NRC) completed a quality assurance (QA) inspection for the GE-Hitachi Nuclear Energy (GEH) computer code design and application of the TRACG, PANAC11, and TGBLA computer codes (see QA Inspection Report 05200010/2008-201) at the GEH Wilmington, North Carolina facilities. Technical staff from the Office of New Reactors and Nuclear Reactor Regulation participated on the inspection team with a focus on code QA activities and code applications for ESBWR safety analyses related to applicable DCD (design certification document) chapters. On January 13, 2009, NRC staff also performed a follow-up technical review regarding the TRACG04 safety analyses code at the GEH office in Washington, D.C. This memorandum summarizes the staff's review activities pertaining to the ESBWR DCD safety analyses.

A list of attendees is provided in Enclosure 1, and a summary of the meeting, including a list of RAIs briefed during the inspection exit meeting, is provided in a non-proprietary version in Enclosure 2. Enclosure 3 contains a proprietary version of the technical summary.

During continuing review of the ESBWR design certification, staff will be considering information gained during this inspection and subsequent technical review and will communicate any additional issues or requests for information with the applicant on the ESBWR docket.

/RA/

Bruce M. Bavol, Project Manager
ESBWR/ABWR Projects Branch 1
Division of New Reactor Licensing
Office of New Reactors

Docket No. 52-010

Enclosures:
1. Participation Summary
2. Technical Summary (Non-Proprietary)
3. Technical Summary (Proprietary)

cc: See next page (w/o enclosure 3)

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SUBJECT: ESBWR COMPUTER CODE REVIEW TECHNICAL SUMMARY INCLUDING A FOLLOWUP REVIEW SUMMARY FOR THE TRACG04 SAFETY ANALYSIS CODE DATED APRIL 29, 2009

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Participation Summary (December 15 through 19, 2008) & (January 13, 2009)

The following table provides a list of the participants from both NRC and GEH.

Last Name	First Name	Affiliation	12/15/2008 To 12/19/2008	01/13/2009
ALAMGIR	MD	GEH	X	
BAVOL	BRUCE	NRC	X	X
BIELEN	ANDREW	NRC	X	
BOWMAN	SCOTT	GEH	X	
CHEUNG	JAKE	GEH	X	
CHEUNG	CHESTER	GEH	X	
DORN	JACLYN	NRC	X	
ESCAMILLA	JAVIER	GEH	X	
GILMER	JIM	NRC	X	
HECK	CHARLIE	GEH	X	
KAIZER	JOSHUA	NRC	X	
LIPSCOMB	GEORGE	NRC	X	
MARCH-LEUBA	JOSE	ORNL	X	
MARQUINO	WAYNE	GEH	X	
MOEN	STEVE	GEH	X	
MORGAN	MICHAEL	NRC	X	
NAKOSKI	JOHN	NRC	X	
PARHAM	NEIL	GEH	X	
PROCOPIO	ARSENIO	GEH	X	
ROCK	DAN	GEH	X	
SAHA	PRADIP	GEH	X	
SHAH	JIGAR R	GEH	X	
SHIRALKAR	BHARAT	GEH	X	
SOLMOS	MATT	GEH	X	
WANG	WEIDONG	NRC	X	
YANG	JENNY	GEH	X	
YARSKY	PETER	NRC		X

Enclosure 1

Technical Summary (Including Exit Meeting Discussions) for the TRACG Computer Code

Introduction

From December 15, through December 19, 2008, technical staff from the Office of New Reactors and Nuclear Reactor Regulation participated in an inspection of GEH's computer code design and application of the TRACG, PANAC11, and TGBLA computer codes for ESBWR safety analyses related to applicable DCD chapters at the GEH Wilmington, North Carolina facilities. In conjunction with this inspection, the NRC team also conducted a review of selected information relevant to requests for additional information (RAIs) 21.6-96, 21.6-98, 21.6-103, 6.3-65, 21.6-44, 21.6-90, 21.6-101, 6.3-62, 21.6-113, 21.6-92, 21.6-123, and 21.6-109 and held an exit meeting with GEH at the conclusion. The results of this onsite review are discussed below.

Agenda Item 1: MFN 08-644 contains a comparison between test data and Versions 40 and 53 of TRACG04. For some of the parameters compared, Version 53 does not yield conservative results compared to Version 40. GEH clarified that this observation is not considered a concern because the Version 53 results are still within the uncertainty of the calculation when compared to test results. In response to RAI 21.6-96, Supplement 01, GEH provides a subset of the TRACG qualification studies comparing test data to Version 40 and Version 53. As a follow-up to the onsite review, RAI 21.6-96 S02 was issued and included include the following:

The response to RAI 21.6-96 S01 provided assessment comparisons for TRACG04 V53 and TRACG04 V40 against test data. Due to the fact that some assessment results were degraded compared to the earlier versions while some cases were improved, provide qualification justification in an additional column in the tables listed in RAI 21.6-96 S01. Since the latest version of TRACG04 Level-2 code V57.11 was used for DCD safety analysis, provide a similar assessment for V 57.11 to RAI 21.6-9 6 S01. **RAI 21.6-96 S02** was issued in RAI Letter 293 (see ML090070467).

Agenda Item 2: The NRC staff requested a list of all ESBWR design changes since the approval of TRACG as applied to ESBWR loss of coolant accident (LOCA) analyses and justification that the original ESBWR LOCA analysis remains applicable to the current design. This was requested in RAI 21.6-98.

NRC staff reviewed the modeling document for the reactor pressure vessel heat structures. The vessel heat structure modeling included reactor vessel internals, such as core and separator, and vessel wall heat structures in detail. The masses of each of the heat structure components were listed in tables and they are important for modeling the stored energy. The documentation revealed TRACG RPV (reactor pressure vessel) heat sink modeling modifications compared to the previous ESBWR models. Those modifications were due to ESBWR design changes. The feedwater system modeling details were submitted in response to RAI 21.6-103. NRC staff was satisfied with the portions of the information provided by GEH to address agenda item 2. However, **RAI 21.6-103** remains open.

Enclosure 2

<u>Agenda Item 3</u>: During the review of the response to RAI 6.3-65 S01, the staff noted that Figure A-6c in MFN 08-085 shows a sudden isolation condenser (IC) steam flow increase at about 60 hours. The NRC staff requested a justification for the sudden IC steam flow increase from GEH. GEH prepared a presentation that contained the additional figures to justify why the sudden IC steam flow increase occurred. The clarification provided by GEH was satisfactory and **RAI 6.3-65 S01** is resolved.

<u>Agenda Item 4</u>: Comparison of [[ ]] the transient boron buildup in the central regions of the core. This would decrease reactivity, therefore decreasing the amount of heat produced in the core, which is non-conservative. Provide justification for the acceptability of these results. This NRC staff question was documented in RAI 21.6-44 S01 and in RAI 21.6-90. Responses to these RAIs (in MFN 08-659 and MFN 08-660, respectively) show that while the total mass of boron in the core for the TRACG calculation is higher than that for the CFD calculation, the TRACG calculation concentrates the majority of the boron in the periphery of the core. Therefore, the boron concentration in the middle of the core for the TRACG calculation is lower, resulting in a conservative calculation with respect to LOCA. NRC staff was satisfied with the portions of the information provided by GEH to address this agenda item. However, **RAI 21.6-90** remains open. The clarification provided by GEH for **RAI 21.6-44 S01** was satisfactory and this RAI is resolved.

<u>Agenda Item 5</u>: Provide justification why the PANDA M-series test M3 flow in PCCS3 [[ ]].

The justification given for the PANDA M-series test M3 flow in PCCS3 [[ ]] is because the flow at that time [[ ]] used in the test. Additional information is contained in NEDC-32725P, "TRACG Qualification for SBWR" Volume 2, Page 5.7-26, which was provided to the staff by GEH during the inspection. NRC staff was satisfied with the clarification provided by GEH.

<u>Agenda Item 6</u>: Provide the reason why some TRACG04 results [[ ]] for the GIRAFFE GS1 test.

This question is addressed in GEH's response to RAI 21.6-101 S01 (MFN 08-707). The response states that the amount of non-condensable gas in the drywell is [[ ]] in TRACG due to the 1-D components in the drywell annulus and the nodalization that was originally used in the TRACG model. The nodalization was updated in MFN 08-707 and the results showed that with the updated nodalization, the [[ ]] to the GIRAFFE GS1 test results. NRC staff was satisfied with the additional information provided by GEH. **RAI 21.6-101 S01** is resolved.

<u>Agenda Item 7</u>: Since GEH does not perform [[ ]], event for containment pressure or RPV water level explain how uncertainty is bounded by the calculation.

NRC staff and GEH discussed how uncertainties are treated for TRACG LOCA analysis, containment pressure, and RPV water level calculations. GEH stated that they have three separate input decks: 1) nominal, 2) level bounding inputs, and 3) containment pressure bounding inputs. The level bounding input deck and the containment pressure bounding input deck (used for the RPV water level calculation and for the containment pressure calculation, respectively) are compared to the nominal input deck to ensure that sufficient uncertainty is provided. NRC staff was satisfied with the information provided by GEH to address this agenda item.

<u>Agenda Item 8</u>: NRC staff requested additional information as to why very small breaks are not limiting.

GEH explained that they do not take [[ ]] for licensing basis calculations. As the size in the break gets smaller, it takes more time for the reactor water level to reach level 1. Longer time to reach level 1 means that there is less decay heat and lower RPV pressure when the automatic depressurization system (ADS) engages. Therefore, the reactor has lower energy and less fluid lost through the break resulting in a greater amount of fluid at a lower temperature remaining in the RPV when gravity driven cooling system (GDCS) begins to inject, which is conservative with respect to LOCA calculations. NRC staff was satisfied with the information provided by GEH to address agenda item 8.

<u>Agenda Item 9</u>: Review GEH's sensitivity studies comparing the RPV level calculations [[ ]] to verify that the changes don't occur until 10 hours into the calculation and that changes demonstrated late in the transient don't significantly impact the results.

These changes made to the ESBWR TRACG input deck are listed in the response to RAI 21.6-98 (MFN 08-545). NRC staff was satisfied with the information provided by GEH to address this agenda item. **RAI 21.6-98 S01** was resolved on 4/14/09.

<u>Agenda Item 10</u>: Discuss decay heat assumption. (RAI 6.3-62)

GEH and NRC staff discussed this item, and it was determined that the text in RAI 6.3-62 response (MFN 07-439) does not reflect the equation relating exposure and irradiation. To address this issue, the staff indicated that they would issue supplemental RAI 6.3-62 S01:

The response of RAI 6.3-62 (A) stated that "Conventionally a higher exposure means a higher fractional fission in plutonium relative to U-235, hence, less decay heat." Another sentence stated that "A longer irradiation means more fission and capture in the fuel, which leads to higher decay heat from fission products and actinides." The above statements are not consistent to the relationship between the exposure and irradiation time in the GEH documents TDP-0159. Provide clarification on decay heat used in the ESBWR LOCA calculation with respect to the fuel exposure and irradiation time. **RAI 6.3-62 S01** was issued in RAI Letter 293 (see ML090070467) – resolved on 4/03/09.

<u>Agenda Item 11</u>: Discuss the stability calculations.

The staff reviewed a number of electronic design record files (eDRFs) related to ESBWR stability calculations in support of the DCD and licensing topical reports, NEDE-33338P, "ESBWR Feedwater Temperature Operating Domain for Transient and Accident Analysis" and NEDO-33337, "ESBWR Initial Core Transient and Accident Analysis."

GEH procedures specify that calculations should be performed with Level 2 (fully qualified with configuration control) codes. These codes have been frozen, qualified, and documented, so that any Level 2 code calculation, when properly documented in an eDRF, can be reproduced in the future. If a Level 2 code is not available for a particular application, GEH procedures allow for the use of a non-fully-qualified Level 1 code version. When a Level 1 code version is used, GEH procedures require an alternative calculation, which often involves either a comparison to an older Level 2 version of the code, or a comparison against experimental data.

Staff review found GEH has adequate documentation of the calculations performed for the DCD and LTRs NEDE-33338P and NEDO-33337. NRC staff was satisfied with the information provided by GEH to address this agenda item.

<u>Agenda Item 12</u>: Discuss Void-Quality correlation issues.

NRC Staff reviewed data in support of the validation of the void-quality correlation used in TRACG. GEH engineers stated that they have obtained additional [[ ]] measurements by analyzing the [[ ]] measurements of prototypical [[ ]]. The new data confirms the applicability of the existing correlations. The staff notes that this work has been performed in support of power up-rates for operating reactors and will be reviewed separately by the staff in that context. NRC staff was satisfied with the information provided by GEH to address this agenda item.

<u>Agenda Item 13</u>: Discuss ESBWR chimney models. (RAI 21.6-113)

NRC staff and GEH discussed RAI 21.6-113 regarding ESBWR chimney models and the response to this RAI which was transmitted in MFN 08-708. As discussed in the RAI response, [[ ]] where flow from several bundles and the bypass region are mixed. GEH provided experimental data in MFN 08-708 that indicates that TRACG [[ ]] in this region by [[ ]]. However, the experimental data provided in MFN 08-708 indicates that after approximately [[ ]] prediction is accurate. GEH justifies why this flow development detail is not important for safe ESBWR operation based on a number of sensitivity calculations, which predict a [[ ]]. For additional information, GEH provided a copy of Reference 2 of MFN 08-708 to NRC staff; this reference documents the additional experimental data of chimney void fraction. NRC staff was satisfied with the information provided by GEH to address this agenda item and **RAI 21.6-113** is resolved.

<u>Agenda Item 14</u>: Discuss the PCT results in GEH LOCA calculations.

NRC staff discussed the LOCA analysis results with GEH engineers and understands that the core remains covered with water during the transients. Therefore, the peak centerline temperature (PCT) in the analysis is near the saturation temperature and no fuel heat up concerns exists. NRC staff is satisfied with the information provided by GEH to address this agenda item.

<u>Agenda Item 15</u>: Discuss the TRACG code versions used in DCD calculations. (RAI 21.6-92 S01)

The code versions used for safety analyses and those versions are documented in the RAI 21.6-92 S01 response. NRC staff said they would issue a supplemental RAI to request GEH to list code versions used for the NEDO-33338P analyses. The text for this supplemental RAI (RAI 21.6-92 S02) is listed below under Agenda Item 17.

Agenda Item 16: During a previous TRACG audit conducted December 15 through 20, 2006, staff reviewed up to and including TRACG Version V52. During this review, staff verified the version starting from V53 up to the present version to determine if there are significant modeling or assessment results changes. Specifically, check the difference between V5704 and V40.

Details about TRACG Versions 53 through 57.11 were discussed with Agenda Item 1. NRC staff was satisfied with the information provided by GEH to address this agenda item.

Agenda Item 17: RAI 21.6-92 listed code versions for DCD Rev. 3. Verify that this table is still applicable to the DCD Rev. 5.

The response to RAI 21.6-92, Supplement 01 (MFN 08-607) provides a list of the TRACG code versions used for the calculations in DCD Revision 5. However, this list is incomplete. As a follow up to the inspection, the staff indicated that they would issue a supplemental RAI as follows:

The response of RAI 21.6-92 S01 provided code versions for DCD safety analysis in a table. Provide a similar table for the code versions used for the NEDE-33338P, "ESBWR Feedwater Temperature Operating Domain for Transient and Accident Analysis." **RAI 21.6-92 S02** was issued in RAI Letter 293 (see ML090070467).

Agenda Item 18: Review changes of qualification from revision 2 to 3 for NEDE-32177P, "TRACG Qualification." NRC staff determined that this item was outside the scope of the onsite review and that it would be addressed separately.

Agenda Item 19: Review sample calculations for an operating limit minimum critical power ratio (OLMCPR) for ESBWR following the procedure from NEDE-33083P, Supplement 3, and "TRACG Application for ESBWR Transient Analysis."

NRC staff and GEH discussed a sample calculation for an OLMCPR for ESBWR referenced by the procedure from NEDE-33083P, Supplement 3. NRC staff is satisfied with the information provided by GEH to address this agenda item.

Agenda Item 20: Review the core loss coefficient change.

The loss coefficient error based on the calculations with the new set of ISCOR and TRACG loss coefficients for spacer grids and the upper tie plate, resulted in a loss of stability margin and higher decay ratios for ESBWR. Corrective actions have been taken to recover these margins. Specifically, GEH has redesigned the core loading to flatten the power profiles. With the new loadings, all acceptance criteria, including stability, are met by the new loading. These updated loss coefficients and core loading will be included in the DCD Revision 6 calculations. NRC staff was satisfied with the information provided by GEH to address this agenda item.

Agenda Item 21: Review the momentum equation accuracy study. (RAI 21.6-123)

The TRACG [[ ]] is addressed in RAI 21.6-123. GEH discussed preliminary results of their accuracy study with the staff. GEH explained that their planned response to RAI 21.6-123 does not include a code change, but will assess the impact safety analyses of the error.

Staff received the response to RAI 21.6-123 on 01/08/09. The staff determined that more detail on the impacts of stability analyses is required, and **RAI 21.6-123 S01** was issued in RAI Letter 311 (see ML090540659).

Agenda Item 22: The staff saw differences between the TRACG02 and TRACG04 prediction of the dry well annulus temperature for the GIRAFFE GS1 test in the TRACG04 software test report (See also agenda Item 6). TRACG04 [[ ]] the dry well annulus temperature for long durations. The staff could not find this plot in the submitted documentation of this test provided in RAI 21.6-101 S01 and asked GEH to explain this behavior.

GEH discussed the changes between TRACG02 and TRACG04. Portions of the response to RAI 21.6-109 (MFN 08-710, 9/22/08) were also provided for additional information. NRC staff is satisfied with the information provided by GEH and **RAI 21.6-101 S01** is resolved.

Agenda Item 23: Review the quality of LOCA calculations.

NRC staff reviewed the overall LOCA safety analysis procedure including verifications when the non-Level 2 codes were applied. NRC staff was satisfied with the information provided by GEH to address this agenda item. (Also see QA Inspection Report 05200010/2008-201)

Agenda Item 24: Topical report NEDE - 32176P, Revision 4, "TRACG Model Description," Section 1.6 (Page 1-4) – staff will confirm that the correction made is a documentation correction, not a correction to the actual TRACG code. Verify the following changes from GEH:

1. Change the mass flux at which the Biasi correlation is used from [[ ]] kg/m^2s. (Section 6.6.6); GEH Response: This is simply a correction to the document not what is actually in the code.

2. Change values of constants [[ ]] based on lattice evaluations. (Section 9.5.1); GEH Response: This corrects typos in the documentation. The code has always been as indicated in the corrected documentation.

GEH staff indicated that for both items, the problem was related to a documentation error and that corrections were only performed in the document, not the actual TRACG code. The NRC staff went through the source code of different TRACG04 versions, and confirmed GEH's response. NRC staff was satisfied with the information provided by GEH regarding this issue.

Exit meeting discussions for the (ESBWR Safety Analyses) TRACG computer code

On December 19, 2008, the NRC team and GEH personnel conducted an exit meeting at the GEH Wilmington, North Carolina facilities. The following RAIs were addressed for the ESBWR safety analyses portion of this meeting.

RAIs:

RAI 21.6-96 S02 was issued in RAI Letter 293 (see ML090070467)

RAI 21.6-98 S01 resolved on 4/14/09

RAI 21.6-103 remains open

RAI 6.3-65 S01 is resolved

RAI 21.6-44 S01 is resolved

RAI 21.6-90 remains open

RAI 21.6-101 S01 is resolved

RAI 6.3-62 S01 was issued in RAI Letter 293 (see ML090070467) - resolved on 4/03/09

RAI 21.6-113 is resolved

RAI 21.6-92 S02 was issued in RAI Letter 293 (see ML090070467)

RAI 21.6-123 S01 was issued in RAI Letter 311 (see ML090540659)

RAI 21.6-109 is resolved

Follow-up Technical Review Summary: Verification Analyses Performed Using Various Versions of the TRACG04 Computer Code

Introduction

On January 13, 2009, NRC staff performed a follow-up technical review regarding the TRACG04 safety analyses code at the GEH office in Washington, DC. During the follow-up technical review, the staff reviewed verification analyses performed using various versions of the TRACG04 computer code. The staff wanted to ensure that the verification analyses were sufficient to justify the use of partially qualified code versions to perform safety analyses for the ESBWR design certification. Table 1 provides the TRACG04 Level 2 and NL2 versions that were employed in the ESBWR safety analysis as well as the platform.

Table 1: TRACG Version Identifier

TRACG Version	QA Level	Platform
T4N1A	Non-Level 2	VMS
T4N1B	Non-Level 2	VMS
T4N2	Non-Level 2	VMS
T4N3	Non-Level 2	VMS
T4-1	Level 2	VMS
T4PN53	Non-Level 2	PC
T4PN5704	Non-Level 2	PC
T4PN5704A	Non-Level 2	PC

According to procedure ESI 30-1.00 “Alternate Calculations for Verification of Non-Level 2 Computer Code Calculations,” verification of analyses performed using NL2 ECPs requires that alternative calculations be performed to ensure the adequacy of the analysis. The staff has reviewed alternative calculations performed for various safety analyses to verify that the procedure was sufficient to ensure that the results of these safety analyses were acceptable. These safety analyses include stability, loss of coolant accident (LOCA), anticipated transients and infrequent events (AOO/IE), and anticipated transients without SCRAM (ATWS). The staff notes that special events, such as station blackout (SBO) were analyzed using a Level 2 version of TRACG04.

Stability

Table 2 provides the NL2 ECPs that were used to perform the stability analysis for the ESBWR as well as the references for the verification analyses. The staff reviewed these references to confirm that the verification of the NL2 ECP was in accordance with the procedures and that comparisons indicated acceptably close agreement to the Level 2 ECP.

T4N2 (Alpha VMS version 45) was validated against data from the Peach Bottom stability tests. This validation is documented in [[ ]]. The staff reviewed the Peach Bottom qualification results and found that updated versions of the code produce essentially the same mean error and standard deviation in the measured [[ ]] results. The mean error difference between the code versions was approximately [[ ]], which is very small compared to the [[ ]]. The difference in the standard deviation was approximately [[ ]]. The staff concurs that the results are essentially identical.

Table 2: Stability Evaluation

Safety Analysis	TRACG version	Verification Analysis
Stability Evaluation (DCD Appendix 4D)		
Baseline Decay Ratio Analysis - BOC	T4N2	[[ ]]
Baseline Decay Ratio Analysis - MOC	T4PN53	[[ ]]
Baseline Decay Ratio Analysis - EOC	T4N2	[[

		]]
AOO Decay Ratio Analysis	T4PN53	[[ ]]
Startup Stability Constant Power Analysis	T4N2	[[ ]]
Startup Stability 3-D Kinetics Analysis	T4N3	[[ ]]

T4N3 (Alpha VMS version 49) was validated against stability data from the [[ ]] event and [[ ]] tests. This validation is recorded in [[ ]]. Version 49 and 50 of TRACG04 were compared to the [[ ]] data. The comparisons confirm that the variation in the decay ratio between the results is well within the expected sensitivity to core flow uncertainties. This indicates an acceptable degree of agreement between the code versions.

T4PN53 (PC version 53) was validated through an alternate calculation using the Alpha Level 2 (version 52) code. This validation is documented in [[ ]]. The comparison indicated very close agreement between the maximum decay ratio (DR) channels. The maximum difference occurs for the channel DRs for the low powered channels. This difference is approximately [[ ]] and that this difference is conservative when the NL2 ECP is used. Therefore, the staff finds that the NL2 version has been adequately verified for use in the safety analyses.

The staff has reviewed the relevant verification package information and has determined that the alternative calculations were acceptable to demonstrate acceptable agreement between the Level 2 TRACG04 code and the NL2 ECP used to perform the safety analysis.

<u>LOCA containment pressurization and emergency core cooling system LOCA analyses</u>

Table 3 provides a summary of the TRACG04 code versions that were used to perform the safety analyses for the pressurization of the containment during LOCA events. Table 4 provides a summary of the TRACG04 code versions that were used to perform the safety analyses for the emergency core cooling system (ECCS) performance during LOCA events. Several NL2 ECPs were used in these analyses. To confirm the applicability, the staff has reviewed the comparison of the NL2 ECPs to the Level 2 TRACG04 version for representative LOCA analyses.

Table 3: LOCA Containment Pressurization Analysis

Safety Analysis	TRACG version	Verification Analysis
LOCA Containment Pressurization Analyses (DCD Section 6.2)		
Feedwater Line Break – Nominal Analysis	T4PN5704A	[[ ]]
Main Steam Line Break – Nominal Analysis	T4PN5704	[[ ]]
GDCS Line Break – Nominal Analysis	T4PN5704A	[[ ]]

Bottom Drain Line Break – Nominal Analysis	T4PN5704	[[ ]]
Feedwater Line Break – Bounding Analysis	T4PN5704	[[ ]]
Main Steam Line Break – Bounding Analysis (0 – 72 hrs)	T4PN5704	[[ ]]
Main Steam Line Break – Bounding Analysis (72 - 168 hrs; 6 PCCS Vent Fans with PARS)	T4PN5704	[[ ]]
Main Steam Line Break – Bounding Analysis (72 - 168 hrs; 4 PCCS Vent Fans with PARS)	T4PN5704A	[[ ]]
Main Steam Line Break – Bounding Analysis (72 - 168 hrs; 6 PCCS Vent Fans without PARS)	T4PN5704A	[[ ]]
Main Steam Line Break – Bounding Analysis (168+ hrs)	T4PN5704A	[[ ]]

Two alternative calculations were performed. The first assesses any impact on the containment pressurization. The [[ ]] was analyzed using the NL2 ECP and the Level 2 TRACG04 code. This event was identified based on the limiting nature of the event in terms of containment pressurization.

The comparisons illustrate the drywell pressure (figure of merit for the calculation) evolution over 72 hours. The comparison indicates essentially identical results over the course of the accident. The staff notes some [[ ]] – however, these are non-limiting points in the accident evolution. The PC version demonstrates a smoother variation in the drywell pressure. Therefore, the staff finds that the accident analysis results over the full 72 hours are essentially identical.

The [[ ]] comparison also considered the drywell (DW), wetwell (WW), and suppression pool temperatures. These results are essentially identical.

Therefore, the staff finds that the alternative calculations performed during the analysis verification demonstrate acceptable performance of the NL2 ECPs for LOCA containment pressurization analysis.

Table 4: ECCS LOCA Analyses

Safety Analysis	**TRACG version**	**Verification Analysis**
ECCS/LOCA Analysis (DCD Section 6.3)		
Feedwater Line Break – Nominal Analysis	T4PN5704	[[ ]]
Main Steam Line Break – Nominal Analysis	T4PN5704A	[[ ]]
Main Steam Line Break – Nominal Analysis (One SRV Failure)	T4PN5704	[[ ]]
Bottom Drain Line Break – Nominal Analysis	T4PN5704	[[ ]]
GDCS Line Break – Nominal Analysis	T4PN5704	[[ ]]

IC Drain Line Break – Bounding Analysis	T4PN5704A	[[ ]]

To evaluate the acceptability of the NL2 ECP for analysis of ECCS/LOCA, the [[ ]] event was considered. The [[ ]] event was considered based on its limiting nature in terms of ECCS performance. The comparisons utilize identical input for the NL2 ECP and the Level 2 code version based on the DCD revision 3 ESBWR plant design.

The comparisons indicate some [[ ]] in the NL2 ECP calculation, however, the predicted collapsed chimney level is essentially identical. The DW, WW, and RPV pressures and the PCC powers are in good agreement. Figure 9 seems to indicate that the non-level 2 version predicts a [[ ]] relative to the figure labeled TRACG04A, Level 2 version. The long term level predicted the TRACG04A version is approximately [[ ]] versus [[ ]] for the non-level 2 version. This was mentioned in the eIV comments section. The TRACG04A figure was revised accordingly and includes direct comparison to the NL2 ECP, therefore, the staff considered only the direct comparisons provided in the figures.

The staff found some [[ ]] in flow and level oscillations during the event, but found that the transient evolution and the final levels were essentially identical.

These are the limiting LOCA events for the subject analyses from the DCD revision 3. These events capture the important phenomena in DCD Section 6.2 and Section 6.3 LOCA analyses. The NL2 ECP and Level 2 ECP comparisons indicate essentially identical results in terms of the figures of merit when the two versions are run with the same input files. Therefore, the staff finds that the use of the NL2 ECP for LOCA analyses is adequate.

<u>Anticipated Operational Occurrences (Transients)</u>

Table 5 provides a summary of the AOO analyses that were performed using NL2 ECPs. The [[ ]] and [[ ]] events were analyzed using the T4PN53 NL2 ECP. The staff reviewed the results of comparative analyses between the NL2 ECP and the Level 2 TRACG04 ECP. The table reports only those transient evaluated with a NL2 ECP.

Table 5: Anticipated Operational Occurrence Analyses

Safety Analysis	**TRACG version**	**Verification Analysis**
Anticipated Operational Occurrence Analysis (DCD Section 15.2)		
Loss of Feedwater Heating	T4PN53	[[ ]]
Inadvertent Isolation Condenser Initiation	T4PN53	[[ ]]

(Only calculations done on non-level 2 versions of TRACG are represented in this table)

To support the application of the T4PN53 NL2 ECP alternative calculations were performed for the [[ ]] AOO. The alternative [[ ]] calculations were provided in the attachment to the [[ ]]. The staff compared the transient plots of the CPR. The figure of merit in the safety analysis is the relative change in critical power ratio (CPR) or the DCPR/ICPR. Agreement in the transient prediction of the channel CPR indicates consistency between the two ECPs. The staff used the Level 2 ECP predicted CPR plot to estimate the DCPR/ICPR predicted by the Level 2 version. The staff estimated this value to be approximately [[ ]], this is in agreement with the NL2 ECP safety analysis results. To provide a better comparison the staff compared the transient plots of key plant parameters: total power, core flow, feedwater flow, steam flow, dome pressure, reactivity, and level. The staff found that these transient parameters were in very close agreement throughout the transient. Therefore, the staff concludes that the analysis results are essentially identical between the Level 2 ECP and the NL2 ECP.

The staff reviewed the eIV in the [[ ]]. The eIV includes a disposition of an error report in the Level 2 version of TRACG04 requiring additional margin of [[ ]] in the DCPR/ICPR calculation. The calculated DCPR/ICPR was increased from [[ ]] to [[ ]] based on the information provided in the eIV. The comparisons provided in the [[ ]] alternative calculation, however, indicate close agreement between the calculated DCPR/ICPR values for AOO analysis. Therefore, the staff finds that the use of the NL2 ECP is acceptable on the basis of essentially identical results and the thermal margin enhancement evaluated for the Level 2 ECP is likewise applicable to the NL2 ECP based on similarity of the codes.

[[ ]] (unlike the operating fleet, which is limited by pressurization transients). The evolution of the [[ ]] AOO is sufficiently similar in terms of the important phenomena to the [[ ]] AOO that the verification against the [[ ]] transient is sufficient to justify the code applicability for evaluation of the limiting transients. Therefore, the staff finds that the use of the NL2 ECP for the AOO calculations has been adequately justified.

<u>Anticipated Transients Without SCRAM</u>

Several special events, namely ATWS events, were analyzed using the T4PN53 NL2 ECP. The staff reviewed the verification analyses performed for the ATWS events that were attached to the eIV for [[ ]]. The verification contains direct comparison of key steady state parameters and other important variables. The staff compared the NL2 ECP predicted steady state parameters to the Level 2 ECP predicted parameters. The staff notes that the steady state solutions are essentially identical. The core average void fraction, flow rates, pressure, and hot channel power densities agreed within [[ ]] significant figures. This indicates acceptable agreement in the steady state convergence.

The staff reviewed transient plots of the ATWS event comparing the NL2 ECP to the Level 2 ECP. Figures were provided in the verification package of the dome pressure, feedwater flow rate and the hot channel CPR. The staff did not consider the comparison of the hot channel CPR as this is not a figure of merit in the ATWS evaluations.

The staff found that the transient pressure and feedwater flows were in excellent agreement between the NL2 and Level 2 ECPs for the first [[ ]] seconds of the transient. The results are essentially identical. The pressurization and flow are macro parameters requiring agreement in the calculated power evolution and mass balance. Therefore, the staff finds that the high degree of agreement in the calculation of these parameters is sufficient to justify the use of the NL2 ECP for ATWS calculations. The close agreement in the feedwater flow rates similarly confirms that the NL2 and Level 2 ECPs predict consistent system response to the automated feedwater runback during the event.

The staff finds that the use of the NL2 ECP for ATWS calculations is acceptable on the basis of the high degree of agreement demonstrated by the verification analyses. The staff notes that special events such as SBO were evaluated using the Level 2 ECP and therefore, alternative calculations for the SBO event were not required.

Conclusions

During the January 13, 2009, follow-up technical review, the staff reviewed alternative calculations performed for safety analyses that included stability, LOCA, AOO/IE, and ATWS to verify that the results of analyses performed with NL2 ECPs were essentially identical to the results of analyses performed using Level 2 ECPs. The staff concludes that the verification analyses were sufficient to justify the use of partially qualified code versions to perform safety analyses for the ESBWR design certification.