Exelon Generation®

10 CFR 50.46

RS-12-100

June 11, 2012

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

Braidwood Station, Unit 2
Facility Operating License No. NPF-77
NRC Docket No. STN 50-457

Byron Station, Unit 2
Facility Operating License No. NPF-66
NRC Docket No. STN 50-455

Subject: Response to Request for Additional Information Regarding Thermal Conductivity Degradation

References:

1. Letter from Michele G. Evans (U.S. NRC) to Michael J. Pacilio (Exelon Nuclear), "Information Request Pursuant to 50.54(f) Related to the Estimated Effect on Peak Cladding Temperature Resulting from Thermal Conductivity Degradation in the Westinghouse Furnished Realistic Emergency Core Cooling System Evaluation (TAC No. M99899)," dated February 16, 2012

2. Letter from Patrick R. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Response to Request for Information Regarding Thermal Conductivity Degradation and 10 CFR 50.46 Report," dated March 19, 2012

3. Letter from Joel S. Wiebe (U.S. NRC) to Michael J. Pacilio (Exelon Nuclear), "Request for Additional Information Related to 10 CFR 50.46 30-Day Report," dated May 10, 2012

Attachment 3 contains Proprietary Information.
Withhold From Public Disclosure Under 10 CFR 2.390.
When separated from Attachment 3, this document is decontrolled.

In Reference 1, the NRC issued an information request for Exelon Generation Company, LLC, (EGC) associated with the effect of thermal conductivity degradation on peak cladding temperature in the Westinghouse Electric Company furnished realistic emergency core cooling system evaluation models for Braidwood Station, Unit 2 and Byron Station, Unit 2. EGC provided the requested information in Reference 2. Subsequent NRC review of Reference 2 has identified the need for the additional information requested in Reference 3.

Attachment 1 to this letter contains the requested information.

Attachment 2 provides Westinghouse letter CAW-12-3496, "Application for Withholding Proprietary Information from Public Disclosure," with accompanying affidavit.

Attachment 3 provides Westinghouse document NF-CB-12-101 Revision 1 P-Attachment, "Byron Unit 2 and Braidwood Unit 2- Response to NRC Formal Request for Additional Information (RAI) from the Reactor Systems Branch Related to the 10 CFR 50.46, 30-Day Report," June 2012 (Proprietary).

Attachment 4 provides Westinghouse document NF-CB-12-101 Revision 1 NP-Attachment, "Byron Unit 2 and Braidwood Unit 2- Response to NRC Formal Request for Additional Information (RAI) from the Reactor Systems Branch Related to the 10 CFR 50.46, 30-Day Report," June 2012 (Non-Proprietary).

As Attachment 3 contains information proprietary to Westinghouse Electric Company LLC, it is supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the NRC and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR 2.390, "Public inspections, exemptions, requests for withholding." Accordingly, it is respectfully requested that the information that is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR 2.390.

Correspondence with respect to the copyright or proprietary aspects of Attachment 3 or the supporting Westinghouse affidavit should reference CAW-12-3496 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, Suite 428, 1000 Westinghouse Drive, Cranberry Township, PA, 16066.

There are no new regulatory commitments made in this letter. If you have any questions about this letter, please contact me at (630) 657-2823.

Respectfully,

Patrick R. Simpson
Manager - Licensing
Exelon Generation Company, LLC

Attachments:

1. Response to NRC Request for Additional Information
2. Westinghouse Affidavit and Authorization Letter CAW-12-3486
3. Westinghouse Document NF-CB-12-101 Revision 1 P-Attachment (Proprietary)
4. Westinghouse Document NF-CB-12-101 Revision 1 NP-Attachment (Non-Proprietary)

cc: Regional Administrator, U.S. NRC Region III
U.S. NRC Senior Resident Inspector, Braidwood Station
U.S. NRC Senior Resident Inspector, Byron Station

ATTACHMENT 1

Response to NRC Request for Additional Information

In Reference 1, the NRC issued an information request for Exelon Generation Company, LLC, (EGC) associated with the effect of thermal conductivity degradation on peak cladding temperature in the Westinghouse Electric Company furnished realistic emergency core cooling system evaluation models for Braidwood Station, Unit 2 and Byron Station, Unit 2. EGC provided the requested information in Reference 2. Subsequent NRC review of Reference 2 has identified the need for the additional information requested in Reference 3.

NRC RAI 1

Provide a table of data that includes the following ASTRUM inputs for AOR and integrated analyses: (1) AOR Run #, (2) TCD Run #, (3) PCT, (4) Time of PCT, (5) Fq, (6) FdH, (7) Cycle Burnup, (8) Margin Only PCT, (9) TCD Minus Margin Only Delta.

Response

The response to NRC RAI 1 is provided in Attachment 3 to this submittal as the response to NRC RAI 1.

NRC RAI 2

Highlight the limiting cases in the ASTRUM run matrices and explain how these cases were chosen. Provide details and explain the approach used to estimate (1) the effects of TCD and (2) the compensating model changes. Justify the selection of the number of WCOBRA/TRAC cases that were re-executed, as opposed to a larger number of cases.

Response

The response to NRC RAI 2 is provided in Attachment 3 to this submittal as the response to NRC RAI 2.

NRC RAI 3

Justify the containment pressure changes made to obtain margin. Provide reference to excerpts from the applicable methodologies to clarify the response.

Response

The response to NRC RAI 3 is provided in Attachment 3 to this submittal as the response to NRC RAI 3.

NRC RAI 4a

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

a. The final paragraph on Page 2 of 9 refers to small differences in fuel characteristics that were claimed to be compared. The paragraph also discusses confirmatory evaluations concluding that other operating characteristics were acceptable. Provide the results of this comparison for Braidwood Unit 2 and Byron Unit No.2, including the relevant conclusions and the technical basis supporting those conclusions. For any conclusion that differences in a particular fuel or operating characteristic are offset by other conservatisms, list those conservatisms and provide a quantitative estimate of each conservatism, as well as a brief description of the rigor associated with that estimate.

Response

The response to NRC RAI 4a is provided in Attachment 3 to this submittal as the response to NRC RAI 4a.

NRC RAI 4b

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

b. Provide the values for the coefficients used in the PAD 4.0 + TCD UO2 thermal conductivity equation.

Response

The response to NRC RAI 4b is provided in Attachment 3 to this submittal as the response to NRC RAI 4b.

NRC RAI 4c

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

c. Explain any error corrections, code improvements, and miscellaneous code cleanup between the WCOBRA/TRAC and HOTSPOT code versions used in the TCD evaluations and those used in the plant's AOR.

Response

The response to NRC RAI 4c is provided in Attachment 3 to this submittal as the response to NRC RAI 4c.

NRC RAI 4d

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

d. What is the thermal conductivity model impact of code version changes in HOTSPOT?

Response

The response to NRC RAI 4d is provided in Attachment 3 to this submittal as the response to NRC RAI 4d.

NRC RAI 4e

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

e. Explain the differences between the HOTSPOT and PAD thermal conductivity models and the impact of those differences. Provide graphs or other quantified descriptions that aid in explanation.

Response

The response to NRC RAI 4e is provided in Attachment 3 to this submittal as the response to NRC RAI 4e.

NRC RAI 4f

Your submittal referenced a March 7, 2012, letter sent by Westinghouse Electric Company to the NRC.

f. Provide additional detail concerning the steady-state ASTRUM/CQD initialization process. In particular, explain what fuel characteristics are adjusted within the applicable models to obtain convergence among HOTSPOT, WCOBRA-TRAC, and PAD 4.0 + TCD.

Response

The response to NRC RAI 4f is provided in Attachment 3 to this submittal as the response to NRC RAI 4f.

NRC RAI 5

Explain how the changed design values will be verified during operation of the plant, i.e., technical specification limits, surveillances, etc. Also, explain what compensatory actions will be taken if a value is found to be outside of the limits assumed in the analysis.

Response

The following Best-Estimate Large Break LOCA (BE-LBLOCA) design input values were modified in the quantitative evaluation performed to assess the PCT effect of TCD and peaking factor burndown for Braidwood Station Unit 2 and Byron Station Unit 2 (Reference 2).

- Upper bound Steam Generator Tube Plugging (SGTP)
- Upper bound nominal vessel average temperature

- Containment pressure boundary condition

Procedures ER-AP-420-002, Revision 10a, "Byron /Braidwood Unit 2: Steam Generator Eddy Current Activities," and ER-AP-420-0051, Revision 15a, "Conduct of Steam Generator Management Program Activities," have been revised to administratively control the upper bound SGTP level. The SGTP level limit of 5% cannot be exceeded without proper evaluation and approval.

EGC's reload process defines the acceptable boundaries within which the reload cycle must comply. This process will be used to reflect the new upper bound nominal vessel average temperature for both Braidwood Station Unit 2 and Byron Station Unit 2. This temperature is chosen to be sufficiently above the nominal vessel average temperature at which Braidwood Station Unit 2 and Byron Station Unit 2 operate.

As discussed in the response to NRC RAI 7, the change in containment pressure boundary condition is a reduction in analysis input conservatism. Verification of margin during plant operation is not required.

The peaking factor burndown included in the quantitative evaluation performed to assess the PCT effect of TCD and peaking factor burndown for Braidwood Station Unit 2 and Byron Station Unit 2 were provided in Reference 2. They are included in this response as Tables 1 to 3.

Table 1: FDH Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FDH[(1)(2)]
0	1.7
28,000	1.7
40,000	1.513
50,000	1.411
60,000	1.326
70,000	1.258

(1) Includes uncertainties.
(2) Hot assembly average power uses same burndown, since it is a function of FDH.

Table 2: Steady State FQ Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FQ Steady-State
0	2.1
30,000	2.1
40,000	1.953
50,000	1.806
60,000	1.722
70,000	1.701

Table 3: Transient FQ Burndown Considered in the Evaluation of TCD

Rod Burnup (MWD/MTU)	FQ Transient[1]
0	2.6
40,000	2.6
50,000	2.314
60,000	2.184
70,000	2.106

(1) Includes uncertainties.

These tables are already included in the cycle specific Reload Safety Analysis Checklist limits. Verification of BE-LBLOCA limits specified in Tables 1 through 3 is performed as part of the normal reload design process for each reload core. Steady state FQ limits are verified by comparing predicted steady-state peaking factors from full power conditions against the steady-state burnup dependent FQ peaking factor limits shown in Table 2. Transient FQ and FDH limits are verified by comparing power distributions predicted for normal operation and for operational transients against the applicable limits specified in Tables 1 and 3. Predicted transient power distributions are generated based on the methodology described in Reference 4. Predicted power distribution used in reload analyses are based on core models developed using the NRC-approved ANC code described in References 5 and 6.

Each reload cycle, these limits are analytically confirmed and verified. If the analytical verification produces unacceptable results, then the core is either redesigned or the BE-LBLOCA analysis is re-performed with revised input parameters. The acceptability of analysis results is based on confirming that the reactor core is operating as designed.

Measured power distributions and core reactivity are compared against predicted power distributions and core reactivity. These comparisons, when coupled with startup physics testing results following refueling, are used to verify the core is operating as designed. This confirmation provides confidence in the predictive capability of the core design model used to verify peaking factors used in BE-LBLOCA accident analysis. If the core is determined to not be operating as designed, an evaluation would be performed to assess analysis margins, understand the reasons for the deviation, and make appropriate adjustments on a case-by-case basis to plant operations or setpoints to ensure operation within BE-LBLOLCA analysis limits.

In summary, transient FQ, FDH, and steady state FQ limits are analytically confirmed for each reload core as part of the reload design process. If peaking factor assumptions to the BE-LBLOCA analysis are exceeded, then either the reload core is redesigned or the BE-LBLOCA analysis is re-performed with revised input parameters. The acceptability of the peaking factors assumptions used in the BE-LBLOCA analysis is confirmed by verifying the core is operating as designed. This is accomplished through a startup physics test program following refueling and through periodic power distribution and reactivity measurements performed throughout the cycle.

NRC RAI 6

At the top of Page 2 of Attachment 1 to your March 19, 2012, submittal, it is stated that, "EGC and its vendor, Westinghouse Electric Company, LLC, utilized processes which ensure that the LOCA analysis input values conservatively bound the as-operated plant values for those parameters." Explain these processes,

Response

The response to NRC RAI 6 is provided in Attachment 3 to this submittal as the response to NRC RAI 6.

NRC RAI 7

Based on the review of your March 19, 2012, submittal it appears that you revised the inputs to a method of evaluation as described in the FSAR (as updated) used in establishing the design bases or in the safety analyses.

Revision 1 to NEI 96-07, "Guidelines for 10 CFR 50.59 Implementation," Section 3.8, "Input Parameters," provides clarifying information concerning whether an input parameter is considered to be an element of a methodology for the purposes of addressing the applicable requirements found at 10 CFR 50.59, "Changes, Tests, and Experiments." Address whether the methodology permits the licensee to establish how to select the value of an input parameter to yield adequately conservative results and whether the revised value is more conservative than that required by the selection method.

Address whether any of the changes (i.e., to the U02 thermal conductivity equation) constitutes a change in the calculational framework used for evaluating behavior or response of a system, structure or component. Explain whether and how 10 CFR 50.59(c)(4) might apply to such a change.

Response

The response to NRC RAI 7 is provided in Attachment 3 to this submittal as the response to NRC RAI 7.

References

1. Letter from Michele G. Evans (U.S. NRC) to Michael J. Pacilio (Exelon Nuclear), "Information Request Pursuant to 50.54(f) Related to the Estimated Effect on Peak Cladding Temperature Resulting from Thermal Conductivity Degradation in the Westinghouse Furnished Realistic Emergency Core Cooling System Evaluation (TAC No. M99899)," dated February 16, 2012

2. Letter from Patrick R. Simpson (Exelon Generation Company, LLC) to U.S. NRC, "Response to Request for Information Regarding Thermal Conductivity Degradation and 10 CFR 50.46 Report," dated March 19, 2012

3. Letter from Joel S. Wiebe (U.S. NRC) to Michael J. Pacilio (Exelon Nuclear), "Request for Additional Information Related to 10 CFR 50.46 30-Day Report," dated May 10, 2012

4. WCAP-9272-P-A, "Westinghouse Reload Safety Evaluations Methodology," July 1985

5. WCAP-10965-P-A, "ANC: A Westinghouse Advanced Nodal Computer Code," September 1986

6. WCAP-11596-P-A, "Qualification of the PHOENIX-P/ANC Nuclear Design System for Pressurized Water Reactor Cores," June 1988

ATTACHMENT 2

Westinghouse Affidavit and Authorization Letter

CAW-12-3496

Westinghouse Electric Company
Nuclear Services
1000 Westinghouse Drive
Cranberry Township, Pennsylvania 16066
USA

U.S. Nuclear Regulatory Commission
Document Control Desk
11555 Rockville Pike
Rockville, MD 20852

Direct tel: (412) 374-4643
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e-mail: greshaja@westinghouse.com
Proj letter: NF-CB-12-101 Revision 1

CAW-12-3496

June 8, 2012

APPLICATION FOR WITHHOLDING PROPRIETARY INFORMATION FROM PUBLIC DISCLOSURE

Subject: NF-CB-12-101 Revision 1 P-Attachment, "Byron Unit 2 and Braidwood Unit 2 – Response to NRC Formal Request for Additional Information (RAI) from the Reactor Systems Branch Related to the 10 CFR 50.46, 30-Day Report" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-12-3496 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Exelon Generation Company, LLC.

Correspondence with respect to the proprietary aspects of the application for withholding or the Westinghouse affidavit should reference CAW-12-3496 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance

Enclosures

CAW-12-3496

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared J. A. Gresham, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

J. A. Gresham, Manager
Regulatory Compliance

Sworn to and subscribed before me
this 8th day of June 2012

Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Cynthia Olesky, Notary Public
Manor Boro, Westmoreland County
My Commission Expires July 16, 2014
Member, Pennsylvania Association of Notaries

(1) I am Manager, Regulatory Compliance, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of

Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use 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 a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390, it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in NF-CB-12-101 Revision 1 P-Attachment, "Byron Unit 2 and Braidwood Unit 2 – Response to NRC Formal Request for Additional Information (RAI) from the Reactor Systems Branch Related to the 10 CFR 50.46, 30-Day Report" (Proprietary) for submittal to the Commission, being transmitted by Exelon Generation Company, LLC letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with fuel thermal conductivity degradation, and may be used only for that purpose.

This information is part of that which will enable Westinghouse to:

(a) Assist customers in providing responses to RAIs dealing with the 10 CFR 50.46, 30-day report.

Further this information has substantial commercial value as follows:

(a) Provide licensing support with respect to thermal conductivity degradation.

(b) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar fuel design and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

PROPRIETARY INFORMATION NOTICE

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for plant-specific review of thermal conductivity degradation impacts.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

COPYRIGHT NOTICE

ATTACHMENT 4

Westinghouse Document NF-CB-12-101 Revision 1 NP-Attachment

(Non-Proprietary)

Byron Unit 2 and Braidwood Unit 2 – Response to NRC Formal Request for Additional Information (RAI) from the Reactor Systems Branch Related to the 10 CFR 50.46, 30-Day Report

June 2012

Westinghouse Electric Company LLC
1000 Westinghouse Drive
Cranberry Township, PA 16066

NRC RAI 1

Provide a table of data that includes the following ASTRUM inputs for AOR and integrated analyses: (1) AOR Run #, (2) TCD Run #, (3) PCT, (4) Time of PCT, (5) Fq, (6) FdH, (7) Cycle Burnup, (8) Margin Only PCT, (9) TCD Minus Margin Only Delta.

Response

Table 1: Byron/Braidwood (CBE/CDE) Integrated TCD Evaluation Runset Data

a,c

a,c

Table 2: Byron/Braidwood Unit 2 (CBE/CDE) AOR Runset Data

a,c

a,c

a,c

a,c

NRC RAI 2

Highlight the limiting cases in the ASTRUM run matrices and explain how these cases were chosen. Provide details and explain the approach used to estimate (1) the effects of TCD and (2) the compensating model changes. Justify the selection of the number of WCOBRA/TRAC cases that were re-executed, as opposed to a larger number of cases.

Response

The cases from the ASTRUM run matrices that were chosen to assess the effects of TCD are highlighted in the response to RAI-CBE-1.

a,c

[ ] a,c

The estimate of effect of the compensating model changes was provided by the difference between the AOR PCT and the Margin PCT. The estimate of effect of TCD was provided by the difference between the Integrated TCD PCT and the Margin PCT.

[ ] a,c

[a,c]

In this evaluation, engineering judgment was applied to select a small runset of limiting cases for the purpose of evaluating the effects of the design input margins and TCD on the Byron and Braidwood Unit 2 large break LOCA PCT. The remaining cases from the ASTRUM AOR which were not explicitly evaluated are expected to remain non-limiting and therefore would not be expected to influence the PCT estimate. The evaluation of TCD and peaking factor burndown supports the full life of the fuel operation.

Table 2-1: [ ]^{a,c} for Byron and Braidwood Unit 2

[a,c

]

Table 2-2: [ ]^{a,c} for Byron and Braidwood Unit 2

[

]^{a,c}

NRC RAI 3

Justify the containment pressure changes made to obtain margin. Provide reference to excerpts from the applicable methodologies to clarify the response.

Response

The analysis of record (AOR) contained 'analysis margin' based on the difference between the COCO (Reference 1) calculated containment backpressure and the WCOBRA/TRAC containment backpressure input. In order to recapture this margin while still assuring a conservatively low containment backpressure, the COCO containment pressure response was calculated with the design input changes (reduced vessel average temperature and assumed steam generator tube plugging) and the analysis margin was reduced by increasing the containment pressure assumed in WCOBRA/TRAC to more closely reflect the calculated pressure. The new containment pressure assumed in WCOBRA/TRAC in the TCD evaluation was compared to the updated COCO calculated pressure consistent with Westinghouse BELOCA analysis guidance and is conservatively low (in accordance with Sections 11-3-1, 11-4-11, and 12-3-4 of WCAP-16009-P-A, Reference 2).

References:

1. WCAP-8327 (Proprietary), WCAP-8326 (Non-Proprietary), "Containment Pressure Analysis Code (COCO)," 1974.
2. WCAP-16009-P-A (Proprietary), "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," January 2005

NRC RAI 4a

The final paragraph on Page 2 of 9 refers to small differences in fuel characteristics that were claimed to be compared. The paragraph also discusses confirmatory evaluations concluding that other operating characteristics were acceptable. Provide the results of this comparison for Braidwood Unit 2 and Byron Unit 2, including the relevant conclusions and the technical basis supporting those conclusions. For any conclusion that differences in a particular fuel or operating characteristic are offset by other conservatisms, list those conservatisms and provide a quantitative estimate of each conservatism, as well as a brief description of the rigor associated with that estimate.

Response

No comparisons were made for Byron Unit 2 and Braidwood Unit 2 Exelon Nuclear Stations. A fuel temperature and rod internal pressure analysis using Exelon specific fuel rod dimensions, plant operating parameters, and rod average linear heat generation using an Exelon specific bounding power history was documented. [

]^{a,c}

NRC RAI 4b

Provide the values for the coefficients used in the PAD 4.0 + TCD UO2 thermal conductivity equation.

Response

The functional form used to model TCD [ ]^{a,c} is as follows:

[a,c]

NRC RAI 4c

Explain any error corrections, code improvements, and miscellaneous code cleanup between the WCOBRA/TRAC and HOTSPOT code versions used in the TCD evaluations and those used in the plant's AOR.

Response

The WCOBRA/TRAC and HOTSPOT code versions used in the evaluation of fuel pellet thermal conductivity degradation do not include any error corrections, code improvements, or model changes from the analysis-of-record code versions.

NRC RAI 4d

What is the thermal conductivity model impact of code version changes in HOTSPOT?

Response

Please refer to the response to 4c above.

NRC RAI 4e

Explain the differences between the HOTSPOT and PAD thermal conductivity models and the impact of those differences. Provide graphs or other quantified descriptions that aid in explanation.

Response

For the fuel thermal conductivity degradation (TCD) evaluation, PAD 4.0 TCD was used to generate the initial maximum fuel average temperature input into WCOBRA/TRAC and HOTSPOT. The PAD 4.0 TCD fuel thermal conductivity equation, for fuel at a nominal density of 95% theoretical density is given in LTR-NRC-12-11 (Reference 1) with the coefficients provided in response to part b) of this request for additional information (RAI) and repeated below.

[a,c

] a,c

For the TCD evaluation, WCOBRA/TRAC and HOTSPOT used a fuel thermal conductivity model based on [ ]^{a,c} For fuel at a nominal density of 95% theoretical density, the model in WCOBRA/TRAC and HOTSPOT is given in LTR-NRC-12-27 (Reference 2) and repeated below.

[a,c

] a,c

The functional form and units between the two models are different. For ease of comparison, the degradation terms (*f(Bu)* in both equations) are compared in Figure 1 at burnups of 20, 40 and 65 GWD/MTU. As seen from Figure 1, [

]^{a,c}

Figures 2 through 5 compare the overall fuel thermal conductivity models at burnups of 0, 20, 40 and 65 GWD/MTU, respectively. Also included in the figures is a comparison with the FRAPCON 3.4 thermal conductivity model (Reference 3). As seen from the figures, [

]^{a,c}

For a given maximum fuel average temperature and burnup, the differences between the PAD 4.0 TCD and WCOBRA/TRAC and HOTSPOT fuel thermal conductivity models [

]^{a,c}

References

1. LTR-NRC-12-11, "Westinghouse Thermal Conductivity Model for Turkey Point Unit 3&4 Extended Power Uprate (EPU) License Amendment Request (LAR) (Proprietary)," February 2, 2012.

2. LTR-NRC-12-27, "Westinghouse Input Supporting Licensee Response to NRC 10 CFR 50.54(f) Letter Regarding Nuclear Fuel Thermal Conductivity Degradation (Proprietary/Non-Proprietary)," March 7, 2012.

3. NUREG/CR-7022, Vol. 1 / PNNL-19418, Vol.1, "FRAPCON-3.4: A Computer Code for the Calculation of Steady-State Thermal-Mechanical Behavior of Oxide Fuel Rods for High Burnup," March 2011.

4. WCAP-12945-P-A, Volume 1 (Revision 2) and Volumes 2 – 5 (Revision 1), "Code Qualification Document for Best Estimate LOCA Analysis," March 1998. (Proprietary)

5. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005. (Proprietary)

Figure 1: Fuel Thermal Conductivity Degradation Model Comparison

[a,c]

Figure 2: Fuel Thermal Conductivity Model Comparisons – 0 GWD/MTU

[a,c]

Figure 3: Fuel Thermal Conductivity Model Comparisons – 20 GWD/MTU

a,c

Figure 4: Fuel Thermal Conductivity Model Comparisons – 40 GWD/MTU

a,c

Figure 5: Fuel Thermal Conductivity Model Comparisons – 65 GWD/MTU

a,c

NRC RAI 4f

Provide additional detail concerning the steady-state ASTRUM/CQD initialization process. In particular, explain what fuel characteristics are adjusted within the applicable models to obtain convergence among HOTSPOT, WCOBRA-TRAC, and PAD4.0 + TCD.

Response

The following twelve parameters in WCOBRA/TRAC are used to determine steady-state convergence, as discussed in Section 20-5 of WCAP-12945-P-A (Reference 1) and Section 12-4-1 of WCAP-16009-P-A (Reference 2).

[a,c]

a,c

References

1. WCAP-12945-P-A, Volume 1 (Revision 2) and Volumes 2 – 5 (Revision 1), "Code Qualification Document for Best Estimate LOCA Analysis," March 1998. (Proprietary)

2. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment Of Uncertainty Method (ASTRUM)," January 2005. (Proprietary)

Table 1: Initial Gap Thickness and Average Fuel Temperature Comparison for Sample 17x17 Plant

[

]a,c

Table 2: Initial Gap Thickness and Average Fuel Temperature Comparison for Sample 15x15 Plant

[

]a,c

Table 3: HOTSPOT and WCOBRA/TRAC Steady-State Gap Heat Transfer Coefficient and Average Fuel Temperature Comparison for Sample 17x17 Plant

[

] a,c

Table 4: HOTSPOT and WCOBRA/TRAC Steady-State Gap Heat Transfer Coefficient and Average Fuel Temperature Comparison for Sample 15x15 Plant

[

] a,c

Figure 1: WCOBRA/TRAC and HOTSPOT Cladding Temperature Comparison for 17x17 Plant

a,c

Figure 2: WCOBRA/TRAC and HOTSPOT Cladding Temperature Comparison for 15x15 Plant

a,c

NRC RAI 6

At the top of Page 2 of Attachment 1 to your March 19, 2012, submittal, it is stated that, "EGC and its vendor, Westinghouse Electric Company, LLC, utilized processes which ensure that the LOCA analysis input values conservatively bound the as-operated plant values for those parameters." Explain these processes.

Response

Exelon and its vendor, Westinghouse Electric Company LLC, ensure the LOCA analysis input values conservatively bound the as-operated plant values for the relevant parameters via the fuel reload process. The purpose of the fuel reload process is to evaluate the plant changes resulting from the loading of different or new fuel into the core. As described in WCAP-9272-P-A (Reference 1), the evaluations performed for the fuel reload support a licensing approach under the regulations of 10 CFR 50.59. Safety Analyses generally analyze the relevant parameters in a bounding direction compared to the expected operational values. The generic fuel reload evaluation approach relies upon the bounding approach in which safety analyses are performed to accommodate the plant changes resulting from different or new fuel in the core without requiring new safety analyses.

As part of the reload evaluation, the LOCA analyst generates a list of important parameters to the LBLOCA analysis, and which show a fuel reload dependency, and identifies the values of those parameters supported by the LBLOCA licensing basis analyses and evaluations. The parameters are confirmed to support the reload core design or are evaluated with respect to the LBLOCA analysis.

Separate from the fuel reload process, plant changes which may impact the LBLOCA analysis are identified to Westinghouse as needed, and 10 CFR 50.46 evaluations are performed as necessary. During the reload process, a summary of plant changes that have occurred since the previous cycle and changes planned for the upcoming cycle is provided by Exelon to Westinghouse. Westinghouse reviews those changes identified by Exelon to ensure the non-reload related parameters analyzed in the LBLOCA analysis, and therefore the LBLOCA analysis, remain applicable. For example, steam generator tube plugging level is one such non-reload related parameter reviewed as part of the reload analysis to ensure that the LBLOCA analysis remains applicable.

References:

1. WCAP-9272-P-A, *Westinghouse Reload Safety Evaluation Methodology*, July 1985.

NRC RAI 7

Based on the review of your March 19, 2012, submittal it appears that you revised the inputs to a method of evaluation as described in the FSAR (as updated) used in establishing the design bases or in the safety analyses.

Revision 1 to NEI 96-07, "Guidelines for 10 CFR 50.59 Implementation," Section 3.8, "Input Parameters," provides clarifying information concerning whether an input parameter is considered to be an element of a methodology for the purposes of addressing the applicable requirements found at 10 CFR 50.59, "Changes, Tests, and Experiments." Address whether the methodology permits the licensee to establish how to select the value of an input parameter to yield adequately conservative results and whether the revised value is more conservative than that required by the selection method.

Address whether any of the changes (i.e., to the UO2 thermal conductivity equation) constitutes a change in the calculational framework used for evaluating behavior or response of a system, structure or component. Explain whether and how 10 CFR 50.59(c)(4) might apply to such a change.

Response

Westinghouse currently employs three best estimate Evaluation Model (EM) methodologies for analysis of the large break loss-of-coolant accidents (LBLOCA) in pressurized water reactors (PWRs):

- 1996 Westinghouse Best Estimate LBLOCA Evaluation Model (Code Qualification Document (CQD) EM, Reference 1)
- 1999 Westinghouse Best Estimate LBLOCA Evaluation Model, Application to PWRs (Pressurized Water Reactors) with Upper Plenum Injection (CQD-UPI EM, Reference 2)
- 2004 Westinghouse Realistic LBLOCA Evaluation Model using ASTRUM (Automated Statistical Treatment of Uncertainty Method) (ASTRUM EM, Reference 3)

In application of a Westinghouse best estimate large break LOCA methodology to a plant analysis, Westinghouse works with the licensee to establish several parameter values input to the specific analysis per the Nuclear Regulatory Commission (NRC) – approved evaluation model requirements (including applicability restrictions specified by the NRC in their Safety Evaluation Reports(SERs)). The licensee is permitted to establish the values of these parameters on the basis of plant-specific considerations; as such they are input to the methodology and not part of the methodology, as defined in NEI 96-07 Revision 1 (Reference 6) Section 3.8. The input parameter values may be selected conservatively in order to support current plant operation, as well as accommodate expected future changes or otherwise at the discretion of the licensee. Table 1 summarizes the selected design input changes evaluated in conjunction with the execution of the thermal conductivity degradation (TCD) evaluation(s) performed as described in the Reference 7 submittal, and relevant governing topical report references identifying how these values are to be selected.

In the evaluations of design input changes performed as described in the Reference 7 submittal, the changes to design input values were made to more closely represent current plant operation. Selection of the revised input parameter values was made in accordance with the approved EM. Therefore, the design input changes reflect reduction in the conservatism of these values and are considered an input parameter change and not a change to the methodology, consistent with Reference 6 Section 3.8. Westinghouse and its licensees utilize processes which ensure that the LBLOCA analysis input values conservatively bound the as-operated plant values for these parameters.

In the evaluations of TCD and design input changes as described in the Reference 7 submittal, analysis input conservatism in the containment pressure input was reduced in order to recover peak cladding temperature (PCT) margin. The as-approved ASTRUM EM specifies that a conservative containment backpressure will be used. The degree of conservatism is not specifically defined by the EM or constrained by the NRC SER. The conservatism retained in the containment backpressure input is specific to each analysis. The magnitude of the conservatism may vary between analyses due to (1) different plant operating parameter ranges considered in each analysis (such as steam generator tube plugging and vessel average temperature), (2) different licensee requirements to accommodate

expected containment changes, and/or (3) different engineering judgment during the analysis execution regarding the need to reduce the input conservatism and recover associated PCT margin in the analysis. This discretionary input parameter conservatism may be recovered while remaining in accordance with the appropriate as-approved EM.

Fuel pellet TCD and peaking factor burndown were not explicitly considered in the as-approved Westinghouse best estimate LBLOCA EMs. In order to evaluate the PCT effect of TCD and peaking factor burndown as described in the Reference 7 submittal, evaluation techniques were used that are outside of the as-approved EMs. This was necessary to explicitly consider the fuel performance effects of TCD, and to adequately evaluate the burnup-dependent aspects of the fuel performance changes considering TCD. Specifically, the following aspects of the TCD evaluation(s) were outside of the as-approved best estimate LBLOCA EM:

[ ] a,c

10 CFR 50.46 establishes criteria for reporting and for action regarding changes or errors involving methods for loss of coolant analyses. For the evaluation and reporting of PCT impact, the changes to the LBLOCA EM to explicitly consider the fuel performance effects of TCD and to adequately evaluate the burnup-dependent aspects of the fuel performance are governed by 10 CFR 50.46. Consistent with 10 CFR 50.59(c)(4) and Reference 6 Section 4.1.1, the provisions of 10 CFR 50.59 do not apply for the LBLOCA EM changes for evaluations and reporting of PCT impact because the 10 CFR 50.46 regulation establishes more specific criteria for reporting and for action for changes involving methods for loss of coolant accidents.

In summary, in the evaluations of TCD and design input changes as described in the Reference 7 submittal, two types of changes were made:

- Design input values were changed to more closely represent plant operation, or analysis input changes were made to reduce conservatism in as-analyzed values. The licensee is permitted to establish the value of these parameters on the basis of plant-specific considerations; as such these are changes to the input of the methodology and are not part of the methodology. Therefore, the design input changes reflect reduction in the conservatism of these values and are considered an input parameter change and not a change to the methodology.

- Techniques to appropriately account for the burnup-dependent effects of TCD were used in the evaluation(s) which are outside of the as-approved EMs. These changes to the calculational framework (as defined in 10 CFR 50.46(c)(2)) were required to assess the TCD phenomena which are not explicitly accounted for in the as-approved EMs. The provisions of 10 CFR 50.59 do not apply for the LBLOCA EM changes for evaluations and reporting of PCT impact because the 10 CFR 50.46 regulation establishes more specific criteria for reporting and for action for changes involving methods for loss of coolant accidents.

Table 1. Applicable Evaluation Model Reference(s) for Selection of the Design Input Parameters Modified in TCD Evaluation for Byron Unit 2 and Braidwood Unit 2

Design Input Change	Relevant Section(s) of ASTRUM Topical Report (Reference 3)
Steam generator tube plugging range	Section 1-2-11 Section 11-3-1
Containment pressure input	Section 11-3-1 Section 11-4-11 Section 12-3-4
Vessel average temperature range	Section 1-2-11 Table 1-11

References:

1. WCAP-12945-P-A, Volume 1, Revision 2, and Volumes 2-5, Revision 1 (Proprietary), Bajorek, S. M. et al., *Code Qualification Document for Best Estimate LOCA Analysis*, March 1998.
2. WCAP-14449-P-A, Revision 1 (Proprietary), Dederer, S. I., *Application of Best Estimate Large Break LOCA Methodology to Westinghouse PWRs with Upper Plenum Injection*, October 1999.
3. WCAP-16009-P-A Revision 0 (Proprietary), Frepoli, C., et al., *Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)*, January 2005.
4. LTR-NRC-12-27, Letter from J. A. Gresham (Westinghouse) to NRC, *Westinghouse Input Supporting Licensee Response to NRC 10 CFR 50.54(f) Letter Regarding Nuclear Fuel Thermal Conductivity Degradation (Proprietary/Non-Proprietary)*, March 7, 2012.
5. Deleted
6. NEI 96-07 Revision 1, *Guidelines for 10 CFR 50.59 Implementation*, November 2000.
7. Letter from P. R. Simpson (Exelon Generation Company, LLC) to NRC, "Braidwood, Unit 2, and Byron, Unit 2, Response to Request for Information Regarding Thermal Conductivity Degradation and 10 CFR 50.46 Report," March 19, 2012. NRC ADAMS Accession Number ML12079A112.