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Our ref: LTR-NRC-06-66
November 29, 2006

Subject: Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation Topical Report WCAP-16500-P, "CE 16x16 Next Generation Fuel Core Reference Report" (TAC No. MD0560)(Proprietary/Non-proprietary)

Enclosed are copies of the Proprietary and Non-Proprietary responses for NRC's Request for Additional Information for WCAP-16500-P/WCAP-16500-NP "CE 16x16 Next Generation Fuel Core Reference Report".

Also enclosed is:

1. One (1) copy of the Application for Withholding, AW-06-2220 (Non-proprietary) with Proprietary Information Notice.
2. One (1) copy of Affidavit (Non-proprietary).

This submittal contains proprietary information of Westinghouse Electric Company, LLC. In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Commission's regulations, we are enclosing with this submittal an Application for Withholding from Public Disclosure and an affidavit. The affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the affidavit or Application for Withholding should reference AW-06-2220 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P.O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Enclosures

cc: R. Landry, NRR
P. Clifford, NRR
H. Cruz, NRR
J. Thompson, NRR

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Our ref: AW-06-2220
November 29, 2006

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: LTR-NRC-06-66 P-Attachment, Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation Topical Report WCAP-16500-P, "CE 16x16 Next Generation Fuel Core Reference Report" (TAC No. MD0560) (Proprietary)

Reference: Letter from J. A. Gresham to NRC, LTR-NRC-06-66, dated November 29, 2006

The application for withholding is submitted by Westinghouse Electric Company LLC (Westinghouse) pursuant to the provisions of paragraph (b)(1) of Section 2.390 of the Commission's regulations. It contains commercial strategic information proprietary to Westinghouse and customarily held in confidence.

The proprietary material for which withholding is being requested is identified in the proprietary version of the subject report. In conformance with 10 CFR Section 2.390, Affidavit AW-06-2220 accompanies this application for withholding, setting forth the basis on which the identified proprietary information may be withheld from public disclosure.

Accordingly, it is respectfully requested that the subject information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR Section 2.390 of the Commission's regulations.

Correspondence with respect to this application for withholding or the accompanying affidavit should reference AW-06-2220 and should be addressed to J. A. Gresham, Manager of Regulatory Compliance and Plant Licensing, Westinghouse Electric Company LLC, P. O. Box 355, Pittsburgh, Pennsylvania 15230-0355.

Very truly yours,

J. A. Gresham, Manager
Regulatory Compliance and Plant Licensing

Cc: R. Landry, NRR
P. Clifford, NRR
H. Cruz, NRR
J. Thompson, NRR

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF ALLEGHENY:

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 and Plant Licensing

Sworn to and subscribed
before me this 29th day
of November, 2006.

Notary Public

Notarial Seal
Sharon L. Fiori, Notary Public
Monroeville Boro, Allegheny County
My Commission Expires January 29, 2007
Member, Pennsylvania Association Of Notaries

(1) I am Manager, Regulatory Compliance and Plant Licensing, 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 rulemaking 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" 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 which 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 "LTR-NRC-06-66 P-Attachment, Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation Topical Report WCAP-16500-P, 'CE 16x16 Next Generation Fuel Core Reference Report' (TAC No. MD0560) (Proprietary)," November 29, 2006, for submittal to the Commission, being transmitted by Westinghouse letter (LTR-NRC-06-66) and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse Electric Company is responses to NRC's Request for Additional Information.

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

(a) Demonstrate the acceptability of the CE 16x16 Next Generation Fuel and corresponding correlation.

(b) Assist customers in implementing an improved fuel product.

Further this information has substantial commercial value as follows:

(a) Westinghouse can use this fuel design with its associated correlation to further enhance their licensing position over their competitors.

(b) Assist customers to obtain license changes.

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 for developing the enclosed improved core thermal performance methodology.

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 generic and/or plant-specific review and approval.

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).

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Response to NRC's Request for Additional Information By the Office Of Nuclear Reactor Regulation Topical Report WCAP-16500-P, "CE 16x16 Next Generation Fuel Core Reference Report" (TAC No. MD0560) (Non-Proprietary)

Westinghouse Electric Company
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355

Request for Additional Information
CE 16x16 Next Generation Fuel Core Reference Report
WCAP-16500-P

Question 1: *The staff's approval of Optimized* ZIRLO™ *(Addendum 1 to WCAP-12610-P-A and CENPD-404-P-A) included a condition whereby Westinghouse demonstrate the continued applicability of their fuel performance models based upon measured LTA data.*

a. Provide a schedule for this demonstration which shows that it remains ahead of the burnups achieved by batch implementation.

b. Figure 2-15 of WCAP-16500-P provides a comparison of adjusted SIGREEP growth predictions against a limited set of measured assembly growth data. Additional measured data (especially up to fluence levels expected at 62,000 MWd/MTU) are required to validate the adjusted SIGREEP calculations. Update Figure 2-15 with additional measured data.

Response 1a: The terms 'Optimized ZIRLO™' and 'Low-tin ZIRLO™' as used in this document and in the past documents refer to material with tin levels of 0.6 to 0.79% which are lower than the lowest allowed tin limit of ZIRLO of 0.8%. All other alloying element levels in the materials referred to as Optimized ZIRLO™ and low-tin ZIRLO™ are same as the originally licensed ZIRLO™. The first use of Optimized ZIRLO™ cladding in Byron LTAs was in a [ ]$^{a, c}$. Subsequent applications of Optimized ZIRLO for cladding are in a [ ]$^{a, c}$ which is currently approved by the NRC for cladding application. In the future, references to low-tin ZIRLO™ will be replaced with Optimized ZIRLO™.

The four listed LTA programs are at different stages of their execution. While the Byron LTA program has concluded, the Calvert-Cliffs, Catawba and Millstone LTA programs are still on-going. The Byron LTA program included both [ ]$^{a, c}$ Optimized ZIRLO™ while the other three LTA programs only included the current [ ]$^{a, c}$ Optimized ZIRLO™. The table below, Table 1-1, provides a summary of the status of the various LTA programs. It should be noted that data and plans associated with future dates are projections and depend on the operation of the plants and thus may change in the future. Data analysis reports will be written in about 9 to 12 months after the LTA inspection data become available.

The listed burnups for the LTAs in Table 1-1 are leading in calendar year of exposure compared to the batchwide exposure of Optimized ZIRLO™. The appropriate LTA data will be checked with the ZIRLO™ model predictions as the data become available.

The projected maximum assembly average burnups for NGF batch implementation at ANO-2 and Waterford 3 are:

ANO-2	Cycle 20	Cycle 21	Cycle 22
Outage Date	Fall 2009	Spring 2011	Fall 2012
Maximum Assembly Average Burnup, MWD/T	27032	48400	-

Waterford 3	Cycle 16	Cycle 17	Cycle 18
Outage Date	Fall 09	Spring 2011	Fall 2012
Maximum Assembly Average Burnup, MWD/T	26697	47438	52844

Response 1b: The data plotted in Figure 2-15 of WCAP-16500-P includes all available measured growth data for guide thimbles fabricated with [ ] a, c ZIRLO™ tubing. The data presented are from two non-NGF LTAs in a foreign CE NSSS reactor after two cycles of operation. In addition to these LTAs, there are four CE 16x16 NGF LTAs with [ ] a, c ZIRLO™ guide thimbles that are about to complete their first cycle of operation in Waterford-3. PIE inspections will include guide thimble growth measurements of the two non-NGF LTAs after their third cycle of operation (Spring '07) and the four NGF LTAs after each cycle of operation (Fall '06, Spring '08, and Fall '09). As these data become available, Westinghouse will compare the PIE data to predictions using the technique described in Section 2.3.1.1 of WCAP-16500-P and modify the correlation if necessary. Westinghouse will keep the NRC informed of progress on these activities through the semi-annual update meetings.

Table 1-1
Optimized ZIRLO™ LTA irradiation and examination status

a, b, c

Question 2: *Westinghouse's FCEP fuel design change process is not currently applicable to CE fuel assembly designs. As such, the staff's approval of the CE 16x16 NGF bundle design must specifically include all variations of the fuel rod and fuel assembly design.*

a. *Figure 1-1 of WCAP-16500-P illustrates 5 possible variances of the CE 16x16 NGF assembly design. Specify, in detail, variations in assembly and component design included in the regulatory envelope for the CE 16x16 NGF design.*

b. *Figure 2-14 of WCAP-16500-P illustrates a single possible variance of the CE 16x16 NGF fuel rod design (Plant B). Specify, in detail, variations in fuel rod design included in the regulatory envelope for the CE 16x16 NGF design.*

Response 2a and 2b: The NGF design was primarily developed for Plant B. Variations in the NGF design are needed due to plant differences. The key differences are summarized below relative to Plant B.

Plant	Difference relative to Plant B
A	Requires an additional mid-grid since existing fuel always utilized an additional grid
B	No difference (Reference Design)
C	Higher seismic requirements at this plant require a modification to selected mid-grids to increase grid strength
D	Top and bottom nozzles are different due to different reactor internals, possible use of higher strength mid-grids at selected locations
E	Fuel assembly length is reduced due to a shorter core

As a result of these differences the distribution of grids with and without mixing vanes and the location of IFM grids change slightly for the different plant designs. Figure 1-1 in WCAP-16500-P summarizes these differences. Table 2-1 provides further detail on the differences.

Table 2-1
NGF Differences for CE 16x16 Plants

	Plant B	Plant A	Plant C	Plant D	Plant E
Fuel Assembly Overall Length	Reference	Same	Same	Longer (consistent with current design)	Shorter (consistent with current design)
Top Grid	Reference	Same	Same	Same	Same
Mid Grids	Reference	Same grid design, 1 additional grid (consistent with current design)	Same number of grids, same grid design at some elevations, higher strength grids at other elevations	Same number of grids, same grid design, except possibly higher strength grids at some elevations	Same grid design, 1 grid less (consistent with current design)
IFM Grid	Reference, number may vary depending upon thermal hydraulic requirements	Same	Same	Same	Same
Bottom Grid	Reference	Same	Same	Same	Same
Top Nozzle	Reference	Same	Same	Similar (differences as necessary due to different internals)	Same except shorter (consistent with reactor internals)
Bottom Nozzle	Reference	Same	Same	Similar (differences as necessary due to different internals)	Same
Outer Guide Thimbles	Reference	Same	Same	Same, except possible enlarged diameter at upper end (like current design)	Same except shorter length (consistent with shorter fuel assembly)
Instrumentation Tube	Reference	Same	Same	Same except for provision for centering ICI	Same except shorter length (consistent with shorter fuel assembly)
Wear Sleeve	Reference	Same	Same	None (consistent with current design)	Same except shorter length (consistent with shorter fuel assembly
Fuel Rod	Reference	Same	Same	Same	Same, except shorter overall and active lengths (active length consistent with current design) and different plenum spring

Question 3: *In many instances, both the Westinghouse suite of models and methods and the CE suite of models and methods have been discussed. The staff's review of CE 16x16 NGF assembly design and supporting implementation methodology addresses both the Westinghouse and CE methods. However, approval of this topical report does not provide a licensee the ability to migrate to reload methodologies beyond their currently approved methods without further NRC review. It is expected that licensees implementing CE 16x16 NGF maintain their currently approved models and methods except where specifically delineated within WCAP-16500-P. Please clarify any deviations from currently approved methods or design criteria being requested as part of the staff's review of WCAP-16500-P.*

Response 3: The deviations from currently approved methods or design criteria in plant licensing basis for WCAP-16500-P are summarized below. If current methodology is not part of plant licensing basis, a plant specific LAR will be provided.

Functional Area **Deviations to current method or design criteria**

Mechanical & Fuel Rod Design

- Use of [ ] a, c on guide thimble growth for [ ] a, c ZIRLO™ guide thimbles
- Use of low tin ZIRLO™ growth data to support grid growth evaluations
- Use of Westinghouse fuel rod growth correlation for shoulder gap evaluations of rods with ZIRLO™ cladding (Reference 1)
- Use of Optimized ZIRLO™ properties (Reference 1) for Optimized ZIRLO™ Mechanical and Fuel rod performance evaluations
- License NGF fuel to a peak rod burnup of 62 MWD/kgU

Nuclear Design

- No deviations
- T-H Design
- Use DNB correlation topical WCAP-16523-P (Reference 2) for NGF fuel
- Application of WSSV & ABB-NV DNB correlations for NGF fuel in VIPRE code
- Application of WSSV-T & ABB-NV DNB correlations for NGF fuel in TORC & CETOP-D codes

Non-LOCA

- Application of WSSV & ABB-NV DNB correlations for NGF fuel in VIPRE code
- Application of WSSV-T & ABB-NV DNB correlations for NGF fuel in TORC & CETOP-D codes
- Possible use of RETRAN, FACTRAN, VIPRE and TWINKLE codes in Non-LOCA safety evaluations

LOCA

- Use of Optimized ZIRLO™ Addendum to CENPD-404-P-A (Reference 1) for Optimized ZIRLO™ LOCA performance evaluations
- Possible use of Best Estimate Large Break LOCA methods defined in WCAP-16009-P-A (Reference 3)
- Grid heat transfer model defined in CENPD-132 Supplement 4-P-A (Reference 4)

Setpoints

- Application of WSSV & ABB-NV DNB correlations for NGF fuel in VIPRE code together with reload methodology defined in WCAP-8745-P-A (Reference 5)
- Application of WSSV-T & ABB-NV DNB correlations for NGF fuel in TORC & CETOP-D codes
- Future use of WSSV, WSSV-T and ABB-NV correlations in the BEACON-COLSS core monitoring system (Reference 6)

Structural

- No Deviations

Radiological

- No Deviations

References:

1. WCAP-12610-P-A and CENPD-404-P-A Addendum 1, "Addendum 1 to WCAP-12610-P-A and CENPD-404-P-A Optimized ZIRLO™," February 2003.
2. WCAP-16523-P, "Westinghouse Correlations WSSV and WSSV-T for Predicting Critical Heat Flux in Rod Bundles with Side-Supported Mixing Vanes," March 2006.
3. WCAP-16009-P-A, "Realistic Large-Break LOCA Evaluation Methodology Using the Automated Statistical Treatment of Uncertainty Method (ASTRUM)," January 2005.
4. CENPD-132 Supplement 4-P-A, Addendum 1-P, "Calculative Methods for the CE Nuclear Power Large Break LOCA Evaluation Model Improvement to 1999 Large Break LOCA EM Steam Cooling Model for Less than 1in/sec Core Reflood," May 2006.
5. WCAP-8745-P-A, "Design Bases for the Thermal Overpower ΔT and Thermal Over-temperature ΔT Trip Functions," September 1986.
6. WCAP-12472-P Addendum 3-A, "BEACON™ Core Monitoring and Operation Support System," June 2006.

Question 4: *Flow induced vibration (FIV) testing is required to quantify flow induced assembly vibration and grid-to-rod fretting. Figure 1-1 of WCAP-16500-P illustrates 5 different combinations of grid strip designs and elevations.*

a. Provide the FIV test results for the different CE 16x16 NGF assembly designs.

b. Provide the FIV test results supporting the mixed-core evaluations.

Response 4a: The fuel assembly hydraulic stability is evaluated using vibration [

] a, c. The single bundle Flow Induced Vibration (FIV) tests for the CE 16x16 NGF and CE 16x16 Standard prototypical assemblies were conducted in the Westinghouse Fuel Assembly Compatibility Test System (FACTS) test loop. Based on previous testing, [

] a, c.

The CE 16x16 NGF design has a mix of non-vaned grids and mixing vane grids that have the side-supported vane (SSV), [

] a, c. To verify that the CE 16x16 NGF design does not have unacceptable fuel assembly flow induced vibration, vibration data were taken during the FACTS hydraulic tests [

] a, c. Plots of the assembly amplitude [
] a, c, Figures 4-1 and 4-2, show very low assembly motion, [ ] a, c, at all elevations for the wide test flow range for both assemblies. For these plots the first non-vaned grid in Figure 1-1 is identified as grid 1. Due to the addition of two IFM grids, Grid 11 for the CE 16x16 NGF assembly is at the same elevation as Grid 9 in the CE 16x16 Standard assembly. These results confirm the excitation source for FIV is not present with the SSV mixing vane for the CE 16x16 NGF fuel designs. Without the excitation source, FIV would not occur for any of the five assembly designs shown in Figure 1-1 for full core conditions.

Response 4b: Following the single bundle tests, a dual test was performed in the Westinghouse Vibration Investigation and Pressure-drop Experimental Research (VIPER) test loop to demonstrate acceptable performance for mixed-core applications. The flow induced vibration test was repeated over a wide range of flows prior to an endurance test to confirm that flow induced fuel assembly vibration was not present at mixing core environment. The [

] a, c.

An endurance test was then performed to confirm improved margin for grid-to-rod fretting with the CE 16x16 NGF grid design. As stated above, [

] a, c. The wear results confirmed the greater margin for grid-to-rod fretting wear for [

] a, b, c.

Since the test results have been acceptable for the [

] a, b, c.

Reference:

1. WCAP-16006, "Examination of Calvert Cliffs Unit 1 Batch R Lead Fuel Assemblies at EOC-15," April 2003.

Figure 4-1

a, b, c

Figure 4-2

a, b, c

Figure 4-3

a, b, c

Figure 4-4

a, b, c

Question 5: *WCAP-16500-P seeks approval of the CE 16x16 NGF fuel assembly design up to 62,000 MWd/MTU. Included in this design is the flexibility to employ different burnable absorbers (e.g. Gd, Er, ZrB_2) and axial zoning (e.g. annular, enrichment). Demonstrate that the currently approved nuclear design and fuel performance analytical models and methods are valid up to 62,000 MWd/MTU for the different fuel rod configurations.*

Response 5: The NGF assembly can employ any of the burnable absorbers, axial (and radial) enrichment zoning, and annular fuel pellets at the top and bottom of the active fuel region. Currently approved Nuclear design and Fuel performance models and methods are applicable and predicted performance parameters must satisfy performance criteria using these models and methods.

The models and algorithms used in the Westinghouse and CE nuclear design codes are based on widely accepted theoretical first principles of reactor physics. The solutions produced by these physics codes do not contain any empirical methods. (Although benchmarks to experiment and plant measurements are used to establish the uncertainty of the predictions.) Consequently, the small extension in burnup from 60 to 62 MWd/kgU will not significantly affect the accuracy of the predictions from these codes.

Further, the Westinghouse physics methodology (ANC, PARAGON, and PHOENIX) has been used for many years for design analysis of Westinghouse NSSS cores with peak fuel rod burnups of up to 62 MWd/kgU. These cores have included both ZrB_2 IFBA and gadolinia burnable absorber types.

The CE physics methodology (ROCS and DIT) has been used for many years for analysis of CE NSSS type cores with peak fuel rod burnups of up to 60 MWd/kgU. These cores have contained both erbia and gadolinia burnable absorbers. In addition ROCS and DIT were also used for the analysis of CE cores containing LTAs to demonstrate acceptability to 62 MWd/kgU and above.

Based on these considerations Westinghouse concludes that the physics models will remain valid for peak fuel rod burnups well beyond 62 MWd/kgU.

The approved fuel performance model, FATES3B, has the capability to accurately treat the impact of burnable absorbers and annular fuel features. Standard UO_2 fuel rods were demonstrated to be acceptably modeled in the design and licensing calculations in Section 2.6 of WCAP-16500-P for CE plants.

The effects of burnable absorbers are discussed in approved topical reports. The addition of gadolinia (CENPD-275-P Revision 1-P Supplement 1-P-A, Reference 1) or erbia (CENPD-382-P-A, Reference 2) will impact the thermal conductivity and melt temperature, but only incrementally from BOL and not burnup dependent. No model or methods changes are required to extend these fuels to 62 MWd/kgU. Similarly, the ZrB_2 burnable absorber model generates helium which is released to the fuel rod plenum and is applicable to 62 MWd/kgU. The geometric effects (thickness) of the ZrB_2 absorber and the model for annular fuel have been reviewed and approved in WCAP-16072-P-A (Reference 3).

Therefore, the models and methodology for the burnable absorbers Gd, Er, and ZrB_2 are applicable to the slightly higher burnups and the fuel rod configurations containing these materials and geometry can be extended to 62 MWd/kgU.

References:

1. CENPD-275-P, Revision 1-P, Supplement 1-P-A, "C-E Methodology for PWR Core Designs Containing Gadolinia-Urania Burnable Absorbers," April 1999.
2. CENPD-382-P-A, "Methodology for Core Designs Containing Erbium Burnable Absorbers," August 1993.
3. WCAP-16072-P-A, "Implementation of Zirconium Diboride Burnable Absorber Coatings in CE Nuclear Power Fuel Assembly Designs," August 2004.

Question 6: *Section 1.2 of WCAP-16500-P states: "The transition core DNBR penalty is more than offset by the available margin from the mixing vane grids". Provide evidence that the DNB margin associated with the mixing vanes always offsets mixed core effects for the CE 16x16 fleet.*

Response 6: The NGF assembly has a higher hydraulic resistance than the co-resident fuel without mixing vanes so flow will be diverted from the NGF assembly resulting in a loss in DNB margin in some locations in the transition core relative to a uniform core. The NGF DNB correlation described in WCAP-16523-P (Reference 1) provides significant DNB overpower margin relative to the current fuel design without mixing vanes (CE-1 or ABB-NV correlation). This increased DNB overpower margin from the NGF DNB correlation will more than offset a DNB penalty associated with flow redistribution in the transition cycle. Utilizing the methodology defined in Section 7 of CENPD-387-P-A (Reference 2) for analyzing transition cores there is at least [ ] $^{a, c}$ DNB overpower margin available after the transition core penalty for flow redistribution is applied to Plant B. These transition core effects will be evaluated and DNB overpower margin will be confirmed in the reload analyses for each plant.

References:

1. WCAP-16523-P, "Westinghouse Correlations WSSV and WSSV-T for Predicting Critical Heat Flux in Rod Bundles with Side-Supported Mixing Vanes," March 2006.
2. CENPD-387-P-A, "ABB Critical Heat Flux Correlations for PWR Fuel", May, 2000.

Question 7: *The fuel assembly designs illustrated in Figure 1-1 of WCAP-16500-P would exhibit axially dependent CHF correlations.*

a. Discuss the methodology for incorporating multiple, axially-dependent CHF correlations into the analog and digital setpoints analysis.

b. Is the application of multiple CHF correlations within the bounds of the approved methodologies and within the scope of the staff's original review?

c. COLSS provides an on-line DNB margin calculation based upon a single, fixed CHF correlation. Discuss the impact of the NGF's multiple CHF correlations on on-line DNB margin calculations. Include a discussion of "actual" versus "indicated" DNB margin as axial power distribution migrates from top peaked to bottom peaked.

d. Describe the impact of NGF's multiple CHF correlations on the analytical calculations of transient DNBR degradation (e.g. required over-power margin).

e. CPCS provides a Low DNBR reactor trip based upon a single, fixed CHF correlation. Describe the impact of NGF's multiple CHF correlations on CPC-calculated DNBR and on how this trip function is credited in safety analysis.

f. Discuss any changes to the analytical approach, inputs, or assumptions within the transient analyses necessitated by the NGF's multiple CHF correlations (e.g. limiting initial axial shape, transient power redistribution).

g. For each of the above items, address mixed cores where co-resident fuel may have different axially-dependent CHF correlations.

Response 7a: Section 6.1 of WCAP-16523-P (Reference 1) described application of axially-dependent CHF correlations for CE-PWR reload analyses, including the analog or digital setpoint analysis. The WSSV/WSSV-T correlation in WCAP-16523-P (Reference 1) is used for the fuel region above the first side-supported vane grids. For the fuel region below the vane grid, or the non-mixing vane region, the ABB-NV correlation in CENPD-387-P-A (Reference 2) is used.

Both WSSV and ABB-NV correlations are incorporated into the VIPRE code (Reference 3) for CE-PWR analysis using the WCAP-9272-P-A approach (Reference 4). The WSSV-T and ABB-NV correlations are incorporated into the TORC code (Reference 5) for CE-PWR analysis using the traditional method. A fast running tool CETOP-D (Reference 6) containing the required DNB correlations can also be used for the setpoint analysis. The CETOP-D DNBR results are conservative as compared to results from more detailed subchannel calculations using TORC or VIPRE.

Response 7b: The licensed methodology for implementing multiple, axially-dependent CHF correlations is described in Section 7 of the ABB-NV/ABB-TV DNB correlation topical (CENPD-387-P-A, Reference 2) for Turbo fuel. The methodology for multiple CHF correlations for NGF fuel is the same as Turbo fuel as described in Section 6 of WCAP-16523-P (Reference 1) and in Section 4 of WCAP-16500-P.

Response 7c: The response to question 7a discusses how multiple, axially-dependent CHF correlations are incorporated into the design thermal hydraulics (TH) codes for CE-PWRs. This discussion applies to the offline TH analysis for CE-PWRs with COLSS. The on-line DNBR algorithm in COLSS will continue to use the CE-1 CHF correlation. The impact of the WSSV-T and ABB-NV correlations on the COLSS margin calculations will be addressed for each plant and cycle in the uncertainty analysis as described in CEN-356(V)-P-A Revision 01-P-A (Reference 7). The plant specific scoping calculations are ongoing and will be available for audit/review in the Westinghouse offices.

Response 7d: The Thermal Hydraulic codes TORC and CETOP-D (used to determine DNBR, minimum DNBR and CHF) include the capability of modeling different CHF correlations for different regions of the hot fuel rod simultaneously. Depending on the placement of differing grid types, the user, via code input, specifies which CHF correlation is applicable for which fuel rod span. For the NGF design, the non-mixing grid region near the bottom of the fuel rod would specify the ABB-NV correlation and the approximate upper two thirds of the fuel rod would specify the WSSV-T correlation. Consequently, irrespective of where the node of minimum DNBR occurs, the correct CHF correlation is applied by TORC or CETOP-D and therefore the correct and accurate DNBR is calculated. This is true whether it's absolute DNBR that's of interest or if it's required overpower margin (ROPM) that's of interest (since Q_{SAFDL} will be based on the CHF correlation where the node of MDNBR occurs) even if the node of MDNBR shifts CHF correlation region.

Based on this, no impact or changes to current analytical methods, calculational approaches, or assumptions are planned with respect to transient analysis of ROPM or DNBR.

Response 7e: Same response as 7c for CPC instead of COLSS.

Response 7f: See response to question 7.d above.

Response 7g: The typical DNB impact of mixed cores was described in response to question 6 and the licensed methodology for evaluating multiple CHF correlations was discussed in response to question 7b. The multiple CHF correlations will be explicitly utilized in the TH codes, VIPER or TORC. The component hydraulic loss coefficients for NGF and co-resident fuel will also be explicitly modeled in the TH codes therefore DNB analyses in transition cores will be accurately evaluated for all operating conditions and axial power shapes.

In the first transition cycle where NGF fuel is implemented the DNB margin gains associated with mixing vane grids will not be fully accounted for in Safety Analyses, therefore many analyses will not be affected. The CETOP-D model for the first transition cycle will be unchanged relative to the current cycle model and will be verified to be conservative relative to TORC code evaluations where transition core effects and new DNB correlations are explicitly accounted for. In subsequent cycles the DNB benefit for mixing vane grids will be fully accounted for in Setpoints and Safety Analyses so the CETOP-D code and model will be modified to explicitly model the NGF assembly and utilize the WSSV-T/ABB-NV DNB correlations.

References:

1. WCAP-16523-P, "Westinghouse Correlations WSSV and WSSVT for Predicting Critical Heat Flux in Rod Bundles with Side-Supported Mixing Vanes," March 2006.
2. CENPD-387-P-A, "ABB Critical Heat Flux Correlations for PWR Fuel," May, 2000.
3. WCAP-14565-P-A Addendum 1-A, "Addendum 1 to 14565-P-A, Qualification of ABB Critical Heat Flux Correlations with VIPRE-01 Code," August 2004.
4. Letter from B. T. Moroney (NRC) to J. A. Stall (FP&L), "St. Lucie Plant, Unit No. 2 – Issuance of Amendment Regarding Change in Reload Methodology and Increase in Steam Generator Tube Plugging Limit (TAG No. MC1566)," January 2005.
5. CENPD-161-P-A, "TORC Code, A Computer Code for Determining the Thermal Margin of a Reactor Core," April 1986.
6. CEN-214(A)-P, "CETOP-D Code Structure and Modeling Methods for Arkansas Nuclear One – Unit 2," July 1982.
7. CEN-356(V)-P-A Revision 1-P-A, "Modified Statistical Combination of Uncertainties," May 1988.

Question 8: *Section 2.3.1.3 of WCAP-16500-P describes component and assembly mechanical testing performed to demonstrate that the CE 16x16 NGF design satisfies design criteria.*

a. Provide a more detailed discussion of the number and types of tests performed along with results. Compare these results to the fuel design criteria.

b. Discuss the impact of irradiation induced spring relaxation on measured grid crush strength testing and the associated Seismic/LOCA load analysis.

Response 8a: Mechanical tests were performed for two reasons: a) to determine fuel assembly mechanical properties that were then modeled in analyses that calculated fuel assembly spacer grid impact loads and component stresses for comparison to the stress limits given in Table 2-2 of WCAP-16500-P; and b) to determine the load carrying capabilities of spacer grids and fuel assembly joints for direct comparison to predicted loads. As indicated in the table below, the tests associated with the first design basis (fuel assembly structural integrity) fit in the first category, and the remaining tests fit into the second category.

Design Basis	Test	Result
The fuel assembly must maintain its structural integrity under all operating conditions.	The following tests were used to establish parameters used in the fuel assembly model in the seismic/LOCA core analysis: 1. Skeleton lateral load-deflection test 2. Fuel assembly lateral-load deflection test 3. Fuel assembly pluck and forced vibrations tests 4. Fuel assembly pluck impact test 5. Fuel assembly axial load-deflection test 6. Grid (Mid grid, top grid, IFM) static buckling strength tests	Fuel assembly model used in CE licensed methodology to determine stresses in the fuel assembly for comparison to applicable stress limits. 1. Strain gage measurements used to benchmark computer code for calculating stresses in guide tubes, fuel rod, and top and bottom nozzles. 2. Stiffness and deflected shapes used to establish fuel assembly model parameters. 3. Natural frequency and damping used to establish fuel assembly model parameters. 4. Used to determine spacer grid one-sided impact stiffness in fuel assembly model. 5. Used to determine axial stiffness of fuel assembly. 6. Used to determine spacer grid thru-grid stiffnesses in fuel assembly model.
The strength of the bulged connections between the guide thimble and the grid sleeves or the guide thimble flange must exceed the loads applied to the connection under all operating conditions.	Mid-grid, IFM grid, and top grid sleeve-to-guide thimble bulge joint strength tests Flange–to-guide thimble bulge joint strength test	All bulged joint strengths exceeded requirements.
Welded connections between the grids and their respective sleeves/inserts must not fail under all operating conditions.	Mid grid, IFM grid, top grid and bottom grid sleeve-to-grid joint strength tests	All welded and brazed joint strengths exceeded requirements.
The lateral strength of the spacer grids must be sufficient to withstand seismic and LOCA events with no channel closure greater than that which would significantly impair the coolability of the fuel rod array or insertability of the CEAs.	Mid-grid and IFM grid one-sided impact strength test Mid-grid and IFM grid long pulse through grid impact strength test Top grid static buckling strength test	The tested grid strengths exceeded requirements.

Response 8b: Grid crush strength testing for the CE 16x16 NGF grids was performed in accordance with Standard Review Plan Section 4.2, Appendix A, which states that unirradiated production grids at (or corrected to) operating temperature shall be tested. In accordance with this direction, BOL spring settings were used.

The effect of spring relaxation, combined with grid growth and rod creepdown, is to create small gaps between the fuel rods and the grid rod support features. The effect of gaps, as well as other irradiation induced effects, on grid seismic capability, is documented in Addendum 1 to WCAP-12488-A (Reference 1), where it was concluded that the continued use of grid crush data from unirradiated production grids to perform seismic/LOCA analysis was validated for Westinghouse grids.

The CE 16x16 NGF spacer grids are similar to Westinghouse grids with respect to the parameters that influence grid strength (material, strap thicknesses, pitch, and straight strap). Therefore, the conclusion from WCAP-12488-A discussed above is also applicable to CE 16x16 NGF spacer grids.

Reference:

1. WCAP-12488-A Addendum 1-A, Revision 1, "Addendum 1 to WCAP-12488-A Revision to Design Criteria," January 2002.

Question 9: *Section 2.4.4 of WCAP-16500-P states that "yield and ultimate strengths of the two materials are almost identical". Provide unirradiated and irradiated YS and UTS for* ZIRLO™ *and current Zircaloy-4 tubing in order to quantify "almost identical".*

Response 9: A comparison of the unirradiated properties is given in the table below. Irradiated properties are not given because stress limits are based on unirradiated properties. Irradiated properties are not used since no credit is included for increased strength due to irradiation.

[ ]a, c

Question 10: *Section 2.5.2 of WCAP-16500-P provides the design basis for fuel rod cladding stress and strain. The staff's SE for Optimized* ZIRLO™ *(WCAP-12610-P-A and CENPD-404-P-A, Addendum 1) [*

]a, c. Clarify the cladding strain design basis.

Response 10: The 1% strain criteria applied to CE plants are based on ensuring that the cladding strain limit is less than the cladding strain capability determined by tensile ductility measurements. The strain evaluation addresses normal operation and application of a limiting AOO.

The cladding's plastic strain and total strain capabilities for Optimized ZIRLO™ decrease with burnup. However, the [

] a, c. Thus, the CE strain criteria presented in the report, as well as in Addendum 1 to CENPD-404-P-A (Reference 1), apply a [

] a, c.

Based on the above discussion, Westinghouse believes the CE strain criteria as stated in the report is appropriate.

Reference:

1. WCAP-12610-P-A and CENPD-404-P-A, Addendum 1, "Addendum 1 to WCAP-12610-P-A and CENPD-404-P-A Optimized ZIRLO™," February 2003.

Question 11: *Section 2.5.7 of WCAP-16500-P describes the fuel rod cladding flattening analysis. The plenum spring radial support capacity is credited in the design analysis. Therefore, the fuel rod plenum spring design is part of the fuel rod design basis and needs to be specifically defined.*

a. Provide the plenum spring specifications for each of the fuel rod designs identified in response to RAI #2.b.

b. Provide justification of each spring's radial support capacity based upon testing.

Response 11a: The Plant B NGF plenum spring design will be used in all plants except Plant E. Nominal spring parameters of the Plant B NGF spring include [

] a, c. The design of the Plant E NGF plenum spring will differ, due to the plants' shorter reactor internals that result in shorter fuel assemblies, fuel rods, and plenum lengths. As a result, some of the Plant E NGF plenum spring parameters will differ from those presented above. The justification of the radial support capability of the Plant E spring design will be established by the technique described below. Any evolutionary changes to the Plant B NGF spring design would be evaluated by this same technique.

Response 11b: The topic of crediting the plenum spring's radial support of the cladding was addressed in WCAP-16072-P (Reference 1) and its related RAIs. Specifically, Round #3 RAI #4 discussed the autoclave testing that serves as the justification of this approach, while the SER on this topic finds the approach acceptable based on, among other things, "a commitment to validate adequate plenum spring support in future applications".

The validation of a particular plenum spring design consists of either an assessment of the spring design relative to previously justified designs or performing additional autoclave tests with the particular plenum spring. The NGF plenum spring design operating in the Waterford-3 LTAs was justified by demonstrating that the results of prior autoclave testing were conservative for the LTA design. Relative to designs that had successfully passed the autoclave tests, the LTA design has the same clad ID, clad thickness, and spring outside diameter, and it has a conservative spring wire diameter (larger), and a conservative spring coil pitch (shorter).

Reference:

1. WCAP-16072-P-A, "Implementation of Zirconium Diboride Burnable Absorber Coatings in CE Nuclear Power Fuel Assembly Designs," August 2004.

Question 12: *Section 2.6 of WCAP-16500-P describes the applicability of the currently approved fuel performance models up to 62,000 MWd/MTU. This section states, [*

] a, c. These two modeling issues may be related since lower fuel temperature will usually result in less fission gas release. Provide further evidence that the currently approved fuel performance models and analytical methodology remain conservative up to 62,000 MWd/MTU.

Response 12: Section 2.6 of WCAP-16500-P provides a description of both fission gas release and temperature predictions relative to measured data. These two models are inter-related since fission gas release is directly dependent on fuel temperatures. Lower fuel temperature would normally result in lower fission gas release. However, the fission gas release data comparisons of Section 2.6 demonstrate that in the FATES3B design and licensing calculations, where power ramps (simulating transients) are applied, conservatively high fission gas release predictions result. Steady-state fission gas release, which is occurring at lower temperatures, is still observed to be generally conservative.

It was also noted in Section 2.6 that while FATES3B under-prediction of temperatures did occur, the under-prediction occurred at such low temperatures that they are not of interest or concern in typical design and licensing. These are low LHGR and fuel temperatures, atypical of plant operation. The fuel thermal conductivity change with temperature is also larger at low LHGR and fuel temperature, sensitizing the predictions. At higher LHGR's the FATES3B trend is to predict the data well. The higher LHGR's are more typical for design and licensing.

Thus, it is concluded that the fuel performance model and methods are applicable to 62 MWd/kgU.