February 2, 2006

Mr. James A. Gresham, Manager
Regulatory Compliance and Plant Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

SUBJECT: FINAL SAFETY EVALUATION FOR WESTINGHOUSE TOPICAL REPORT WCAP-15942-P, "FUEL ASSEMBLY MECHANICAL DESIGN METHODOLOGY FOR BOILING WATER REACTORS - SUPPLEMENT 1 TO CENP-287," REVISION 0 (TAC NO. MC4592)

Dear Mr. Gresham:

By letter dated October 29, 2004, as supplemented by letter dated June 30, 2005, Westinghouse Electric Company (Westinghouse) submitted Topical Report (TR) WCAP-15942-P, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," Revision 0, to the U.S. Nuclear Regulatory Commission (NRC) staff for review. This TR describes improvements to the previously approved boiling-water reactor fuel mechanical design methodology intended to support fuel design and licensing applications up to a rod average burnup of 62 GWd/MTU. This TR also provides a reference product description, including mechanical specifications and performance aspects, of the improved SVEA-96 fuel assembly design, Optima2.

By letter dated November 17, 2005, an NRC draft safety evaluation (SE) regarding our approval of TR WCAP-15942-P, Revision 0, was provided for your review and comment. By letter dated December 7, 2005, Westinghouse commented on the proprietary nature of the draft SE. The NRC staff has addressed Westinghouse's comments and both proprietary and non-proprietary versions of the final SE are enclosed. Also enclosed is a copy of a proprietary Pacific Northwest National Laboratory Technical Evaluation Report which was used in the NRC staff's review of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC website, we request that Westinghouse publish an accepted version of this TR within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE after the title page. Also, it must contain historical review information, including NRC requests for additional information and your responses. The accepted version shall include a "- A" (designating accepted) following the TR identification symbol.

If future changes to the NRC's regulatory requirements affect the acceptability of this TR, Westinghouse and/or licensees referencing it will be expected to revise the TR appropriately, or justify its continued applicability for subsequent referencing.

Sincerely,

/RA/

Richard P. Correia, Acting Deputy Director
Division of Policy and Rulemaking
Office of Nuclear Reactor Regulation

Project No. 700

Enclosures:
1. Final Safety Evaluation (Non-Proprietary)
2. Final Safety Evaluation (Proprietary)
3. Technical Evaluation Report (Proprietary)

cc w/encl 1 only:
Mr. Gordon Bischoff, Manager
Owners Group Program Management Office
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-15942-P

"FUEL ASSEMBLY MECHANICAL DESIGN METHODOLOGY

FOR BOILING WATER REACTORS - SUPPLEMENT 1 TO CENP-287," REVISION 0

WESTINGHOUSE ELECTRIC COMPANY

PROJECT NO. 700

1.0 INTRODUCTION AND BACKGROUND

By letter dated October 29, 2004 (Agencywide Document Access Management System (ADAMS) Accession No. ML043090165), as supplemented by a letter dated June 30, 2005 (ADAMS Accession No. ML051890104 (Reference 1)), Westinghouse Electric Company (Westinghouse) requested review and approval of WCAP-15942-P entitled, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," Revision 0. This topical report (TR) describes improvements to the previously approved boiling-water reactor (BWR) fuel mechanical design methodology intended to support fuel design and licensing applications up to a rod average burnup of 62 GWd/MTU. This TR also provides a reference product description, including mechanical specifications and performance aspects, of the improved SVEA-96 fuel assembly design, Optima2.

The Nuclear Regulatory Commission (NRC) staff's review was assisted by Pacific Northwest National Laboratory (PNNL). The NRC staff's conclusions on the acceptability of WCAP-15942-P are supported by the proprietary PNNL Technical Evaluation Report (TER), which is being withheld from public availability.

2.0 REGULATORY EVALUATION

Regulatory guidance for the review of fuel system designs and adherence to applicable General Design Criteria (GDC) is provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP), Section 4.2, "Fuel System Design" (Reference 2). In accordance with SRP Section 4.2, the objectives of the fuel system safety review are to provide assurance that:

a. the fuel system is not damaged as a result of normal operation and anticipated operational occurrences (AOOs),

b. fuel system damage is never so severe as to prevent control rod insertion when it is required,

c. the number of fuel rod failures is not underestimated for postulated accidents, and

d. coolability is always maintained.

In addition to licensed reload methodologies, an approved mechanical design methodology is utilized to demonstrate compliance with SRP Section 4.2 fuel design criteria. WCAP-15942-P describes improvements to Westinghouse's BWR fuel mechanical design methodology including application of the improved fuel performance computer models (STAV7.2, VIK-3, and COLLAPS II Version 3.3D). The NRC staff's review of WCAP-15942-P is to ensure that the mechanical design methodology adequately addresses the applicable regulatory requirements identified in SRP Section 4.2. In addition, the NRC staff reviewed the SVEA-96 Optima2 fuel assembly design to ensure its performance satisfies these requirements.

3.0 TECHNICAL EVALUATION

The objectives of the staff's review of WCAP-15942-P were to verify that:

- the fuel assembly component and fuel rod design criteria are consistent with regulatory criteria identified in SRP Section 4.2.
- the fuel mechanical design methodology is capable of accurately or conservatively evaluating each component with respect to its applicable design criteria.
- the reference SVEA-96 Optima2 fuel assembly design satisfies the regulatory requirements.
- the Westinghouse experience database supports the operating limits being requested.

Sections 3.2, 3.3, and 3.4 describe the staff's review of Westinghouse's BWR fuel assembly and fuel rod design criteria supporting a peak rod average burnup of 62 GWd/MTU. Licensees must ensure that all of these design criteria are satisfied on a cycle-specific basis (See Section 4.0, Item #1).

3.1 SVEA-96 Optima2 Fuel Assembly Design

WCAP-15942-P provides the fuel mechanical design criteria and methodology along with a "sample application" for the new SVEA-96 Optima2 fuel assembly design. The NRC staff had a question with regard to the level of review/approval being sought on the new fuel assembly design. In response to the request for additional information (RAI) No. 7, Westinghouse stated that they were "seeking approval of WCAP-15942 as defining the reference product description to be used by licensees as a reference document in license amendment requests."

Section 2 of WCAP-15942-P provides a description of the reference Optima2 fuel assembly design and is supported by detailed illustrations in Figures 2-1 through 2-14. To further define the regulatory definition of Optima2, the NRC staff asked Westinghouse to identify all of the plant-specific fuel assembly design changes and the range of their variation. In response to RAI No. 7, Westinghouse identified four areas of the mechanical design that potentially require plant-specific changes to ensure mechanical compatibility with core components and co-resident fuel. The range of variability for these compatibility features of the Optima2 design was also included in the response.

Westinghouse currently does not have an approved fuel design change process (similar to FCEP, WCAP-12488-P-A) for their BWR fuel designs. As such, modifications to the fuel assembly design, beyond the mechanical compatibility changes identified in the response to

RAI No. 7, may invalidate the NRC staff's approval of the SVEA-96 Optima2 reference fuel design. As part of their license amendment request, licensees must describe any plant-specific changes to the reference SVEA-96 Optima2 assembly design and demonstrate that these changes are within the envelope reviewed by the staff (See Section 4.0, Item #2a).

The "Advanced Features" in Section 2.5 of WCAP-15942-P are not currently part of the Optima2 design and were not included in this review (See Section 4.0, Item #2b).

Optima2 Operating Experience

Historically, the NRC staff has relied on Lead Test Assembly (LTA) programs to generate in-reactor operating experience for new assembly design features or materials. Although Westinghouse has not employed Optima2 LTAs in U.S. BWRs, extensive operating experience has been acquired via LTA programs and full reload batch applications in European BWRs. In response to RAI No. 11, regarding in-reactor experience, Westinghouse provided a complete history of operating experience for the entire SVEA 10x10 family of fuel designs (e.g., SVEA96 / 96+ / 100, Optima, and Optima2). This extensive database includes more than 13,000 fuel bundles. Note that many of the assembly components and materials employed in the Optima2 bundle design are identical to past SVEA fuel designs. Therefore, this past operating experience is directly applicable to this review. Examination of Figure 7-2 of WCAP-15942-P, which provides a distribution of operating experience as a function of assembly burnup, reveals that this operating database includes a sufficient number of SVEA fuel assemblies beyond the burnup limit requested by Westinghouse.

The Westinghouse operating experience database includes more than 1,500 Optima2 fuel bundles first introduced as LTAs in 2000. The maximum assembly burnup on the Optima2 fuel bundles is approaching the burnup limit requested by Westinghouse.

In order to verify that the European operating experience was directly applicable to U.S. BWRs, the NRC staff requested a comparison of operating characteristics. In response to RAI No. 11, Westinghouse provided a comparison of licensed plant power, bundle average power, core flow, local power peaking factors, average flow per bundle, and exit quality for the European and U.S. BWRs.

Based on the information presented in WCAP-15942-P and the response to RAI No. 11, the NRC staff finds the operating experience database supporting the Optima2 fuel assembly design review is of sufficient breadth to cover the range of burnup and operating conditions being considered. Further, it has been demonstrated that this experience is directly applicable to U.S. BWRs.

3.2 General Design Criteria

Westinghouse has established fuel mechanical design requirements and a supporting methodology which satisfy the applicable General Design Criteria (GDC)-10, 27, and 35 and the requirements outlined in SRP Section 4.2. A specific application of these design criteria and the methodology to the SVEA-96 Optima2 fuel design is included.

Section 3.1.1 of WCAP-15942-P identifies the design criteria for normal operations and AOOs. The design criteria in this section are unchanged from CENPD-287-P-A. In Section 3.1 of the TER, PNNL concludes that the design criteria are consistent with GDC-10 as specified in SRP

Section 4.2 and are acceptable for application to SVEA-96 designs. Based on compliance to SRP Section 4.2 guidance and PNNL's technical assessment, the NRC staff finds the design criteria for normal operation and AOOs acceptable.

Section 3.1.2 of WCAP-15942-P identifies the design criteria for accident conditions. With the exception of a change to highlight Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50.46 acceptance criteria and anticipate a change to the control rod drop regulatory requirements, the design criteria for fuel rod mechanical failure, fuel coolability, clad bursting, and excessive fuel enthalpy are unchanged from CENPD-287-P-A. In Section 3.2 of the TER, PNNL concludes that the design criteria are consistent with SRP Section 4.2 and are acceptable for application to SVEA-96 designs. Based upon compliance to SRP Section 4.2 guidance and PNNL's technical assessment, the NRC staff finds the design criteria for accident conditions acceptable.

The remaining sections of the TR (Design Criteria, Evaluation Methodology, New Design Features, Post-Irradiation Fuel Examinations, New Safety Issues, Failure to Satisfy Criteria, and Burnup) remain unchanged from CENPD-287-P-A. In Sections 3.4, 3.6, and 3.7 of the TER, PNNL notes that the methodology has not been reviewed with respect to new design features and therefore changes to the Optima2 assembly design or design criteria would require additional NRC review. The NRC staff agrees with this assessment.

3.3 Assembly Components Design Criteria

Westinghouse has identified nine specific criteria for fuel assembly components. These design criteria, the supporting methodology, and application to the sample Optima2 fuel assembly design are discussed below. As described in Section 3.1 of WCAP-15942, plant-specific changes are required to ensure mechanical compatibility with core components and co-resident fuel. As a result, each licensee must ensure that all of the design criteria are satisfied for their specific Optima2 fuel assembly design.

3.3.1 Compatibility with Other Fuel Types and Reactor Internals

The Westinghouse criterion for compatibility with other fuel types and reactor internals is that mechanical compatibility with core components and internals is required such that components are not damaged and can perform their intended functional requirements. This criterion is not discussed in the SRP. However, PNNL has reviewed this criterion and concludes that this criterion is acceptable for application to SVEA-96 designs.

Section 4.2.1 of WCAP-15942-P describes the methodology associated with mechanical compatibility and provides an application for Optima2. In Section 4.1.1 of the TER, PNNL reviewed the methodology associated with the five mechanical compatibility evaluations and concluded that they were acceptable for application to SVEA-96 fuel designs. With regard to Optima2, PNNL concluded that since plant dimensions and co-resident fuel types vary, each licensee will need to perform the evaluation following the approved methods.

<u>Control Blade Interference</u>

WCAP-15942-P includes a sample application for Optima2 of the methodology for evaluating control blade interference due to channel bulge and channel bow. In response to RAI No. 14, regarding the applicability of the limited SVEA-64 channel bulge database to SVEA-96 channels, Westinghouse included a discussion of the differences between the SVEA-64 and SVEA-96 channels. In addition, Westinghouse provided 10x10 SVEA Zircaloy-2 channel bulge measurement data from a European BWR/6 out to a burnup beyond the limit requested. A comparison of the 10x10 measurements to the creep correlation demonstrates that the bulge predictions remain conservative up to the burnup limit requested, which reinforces the SVEA-64 comparison in Figure 4.2-5 of WCAP-15942-P. Based on the information presented in WCAP-15942-P and the response to RAI No. 14, the NRC staff finds the creep correlation acceptable.

In Section 4.1.1 of the TER, PNNL examined the channel bow data, the standard deviation of the bow data, and the control blade clearances calculated by Westinghouse and concluded that further justification was required. In response to RAI No. 15, Westinghouse provided additional channel bow measurements, an increased estimate of channel bow based upon the entire database, and a revised methodology for evaluating control blade interference. Westinghouse has also suggested the following revised criterion for SVEA fuel designs:

> Control blade interference due to the combined effects of channel bow and creep will be sufficiently low during the life of the fuel bundle to ensure with high confidence that maximum SCRAM insertion times for operable rods given in the technical specifications are not exceeded.

To support this new design basis, Westinghouse has provided control rod insertion surveillance data from the [ ] BWR/6 plant. The NRC staff has independently plotted this insertion data as a function of maximum 1-assembly, average 4-assembly, and maximum 2-assembly burnup all versus insertion time (See figures below). The [ ] insertion requirement is 1.4 seconds to notch position 13, which corresponds to 73 percent insertion. This requirement is similar to U.S. BWR/6 technical specifications (TSs). Examination of the figures below reveals no strong relation between insertion times and burnup. Westinghouse stated that this trend "confirms that even for large channel bows, the SVEA channel is flexible enough to not impact the SCRAM times" (The response to RAI No. 15). [ ] has performed extensive channel bow measurements and rod insertion time measurements. [ ] has always had a control blade meet TS requirements (< 1.4 seconds) for SCRAM insertion times and reports they have no history of experiencing slow rods (1.4 seconds < t < 2.09 seconds) for any SVEA channels. Furthermore, [ ] has not experienced any sticking problems with control rod withdrawal. In one instance, [ ]'s experience has demonstrated the ability to meet insertion speed requirements on a channel with excessive bow.

Westinghouse has proposed a methodology to demonstrate the applicability of the [ ] experience to U.S. BWRs, explicitly accounting for plant-specific differences. The calculated control blade interference for the U.S. application (based on predicted creep and projected channel bow) would be shown to be less than that experienced by [ ]. PNNL has reviewed the proposed methodology for evaluating control blade interference and finds it acceptable.

Several conditions were developed to ensure the continuing applicability of this methodology. In addition, both PNNL and the NRC staff had concerns that a burnup-dependent channel bow may not have been captured by the limited number of high burnup insertion measurements (See Section 4.0, Items #4a, #4b, and #4c). Specifically, examination of the 4-assembly average burnup data (see the plot below) reveals that the database is limited to a 4-assembly average burnup of 36,000 MWd/MTU. The NRC staff was concerned that differences in fuel utilization between U.S. BWRs and European BWRs may result in the placement of adjacent, higher burnup assemblies whose potential to experience a channel bow is greater. To address this concern, an additional condition was developed to inform the NRC staff of any "slow" control rod insertion indications at U.S. BWRs with SVEA channels (See Section 4.0, Item #4d).

Based on the information presented in WCAP-15942-P, as supplemented by responses to RAI No. 15 and PNNL's technical evaluation, the NRC staff finds the revised control rod interference criteria, methodology, and sample application to Optima2 acceptable.

[

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3.3.2 Geometric Changes in the Assembly during Operation

The Westinghouse criterion for geometric changes in the assembly is that geometry changes during the life of the fuel assembly components must not interfere with or impair the performance of other components. This includes sufficient clearances between the fuel rods and upper tie-plate to prevent an interference fit or disengagement from the upper tie-plate. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.2 of WCAP-15942-P describes the methodology associated with evaluating in-service dimensional changes and provides an application for Optima2. In Section 4.1.2 of the TER, PNNL reviewed the methodology associated with the three typical dimensional compatibility evaluations and concluded that they are acceptable for application to SVEA-96 fuel designs.

With regard to Optima2, PNNL concluded that the experience database is sufficient to demonstrate sufficient design margin for Optima2 to account for sub-bundle and differential fuel rod growth. PNNL stated that the evaluations performed on assembly components are either limiting for U.S. applications or demonstrate that sufficient experience exists to conclude that the components will not violate their criteria. Based on the information presented in WCAP-15942-P, the response to RAIs and PNNL's technical evaluation, the NRC staff finds the in-service geometric changes criteria, methodology, and sample application to Optima2 acceptable.

3.3.3 Transportation and Handling Loads

The Westinghouse criterion for transport and handling loads is that assembly components shall be able to withstand handling and shipping loads without damage. This criterion is not discussed in the SRP. However, PNNL has reviewed this criterion and concludes that this criterion is acceptable for application to SVEA-96 designs.

Section 4.2.3 of WCAP-15942-P describes the methodology associated with transportation and handling loads and provides an application for Optima2. In Section 4.1.3 of the TER, PNNL reviewed the methodology associated with ensuring that assembly components are able to withstand handling loads without damage and concluded that it is acceptable for application to SVEA-96 fuel designs. PNNL's technical evaluation did not include transportation loads which need to be addressed in a separate review on shipping container design.

PNNL assessed the stress evaluations on the Optima2 assembly components which were performed with the approved Finite Element Analysis (FEA) code ANSYS. PNNL concluded that the FEA demonstrates that the handling loads are substantially less than the limiting loads for fuel handling. Each licensee will need to perform this analysis on a site-specific basis to confirm this conclusion. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the handling loads criteria, methodology, and sample application to Optima2 acceptable. Transportation loads were not included as part of this review.

3.3.4 Hydraulic Lifting Loads During Normal Operations and Anticipated Operational Occurrence (AOOs)

The Westinghouse criterion is that hydraulic lift loads on the assembly during normal operation and AOOs are not sufficient to unseat the assembly bottom nozzle from the fuel support piece. The impact of these hydraulic lift forces on the sub-bundles are also evaluated to confirm that they are insufficient to unseat sub-bundles from the lower support piece in the bottom nozzle. PNNL concluded that this criterion is consistent with SRP Section 4.2 and applicable to SVEA-96 fuel designs.

Section 4.2.4 of WCAP-15942-P describes the methodology associated with hydraulic lift loads and provides an application for Optima2. Westinghouse states that conditions which provide maximum hydraulic lift loads during normal operation and AOOs are identified for each plant application for a given assembly design. In Section 4.1.4 of the TER, PNNL reviewed the hydraulic lift loads methodology, which relies on an approved core thermal-hydraulic code, and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL evaluated the example calculation on SVEA-96 Optima2 in a BWR/6 at uprated conditions and concluded that, for the given example case, Optima2 will not violate the criterion. PNNL noted that a plant-specific analysis for channel bypass flow hole size and reactor application must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the hydraulic lift criterion, methodology, and sample application to Optima2 acceptable.

3.3.5 Stress and Strain During Normal Operations and AOOs

The Westinghouse criterion for assembly stress and strain is that assembly component mechanical failure shall not occur. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.5 of WCAP-15942-P describes the methodology associated with evaluating component stress and strain and provides an application for Optima2. In Section 4.1.5 of the TER, PNNL reviewed the methodology for ensuring that excess stress or strain does not result in mechanical failure in assembly components and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL evaluated the example stress analyses on SVEA-96 Optima2 which considered the external compression spring, spacer spring, and fuel channel. Expected stresses on the other assembly components were bounded by shipping and handling loads. PNNL concluded that the mechanical tests and in-reactor performance confirm that the spacer and external compression spring will not fail in SVEA-96 Optima2 due to operational stress. PNNL also concluded that the FEA shows that the stresses will not fail the Optima2 channel during normal operation and AOOs. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the stress and strain evaluation criterion, methodology, and sample application to Optima2 acceptable.

3.3.6 Fatigue During Normal Operations and AOOs

The Westinghouse criterion for fatigue of assembly components is that fatigue failure shall not occur. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.6 of WCAP-15942-P describes the methodology associated with evaluating fatigue failure of assembly components and provides an application for Optima2. The design fatigue curve includes the more conservative of a factor of 2.0 on stress amplitude or 20 on the number of cycles. The calculated cumulative usage factor must be less than 1.0 for the design life of the fuel. Note that the only component in the assembly, other than the fuel, that experiences stress cycling that can result in strain fatigue is the fuel channel. In Section 4.1.6 of the TER, PNNL reviewed the fatigue methodology, which specifically accounts for thinning due to corrosion, and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL evaluated the example fatigue analyses on the SVEA-96 Optima2 fuel channel, as well as results from a pressure cycling test (Section 8.2 of WCAP-15942-P), and concluded that the example case will not violate the criterion during normal operation and AOOs. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the assembly fatigue evaluation criterion, methodology, and sample application to Optima2 acceptable.

3.3.7 Fretting Wear of Assembly Components

The Westinghouse criterion for fretting wear of assembly components is that fuel rod failure due to fretting shall not occur in an environment free of foreign material (debris). Assembly fretting wear must be accounted for in evaluating stress and fatigue limits. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.7 of WCAP-15942-P describes the methodology and strategies for avoiding fretting failure and provides an application for Optima2. Westinghouse employs a combination of design features, in-reactor experience, and full-scale hydraulic endurance testing to avoid fretting wear. In Section 4.1.7 of the TER, PNNL reviewed the methodology and strategies for avoiding fretting wear and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the fretting evaluation for the SVEA-96 Optima2 fuel design. In addition to maintaining beneficial features and materials from previous designs, Westinghouse has performed full-scale fretting tests for single-phase and two-phase flow conditions (Section 8.1 of WCAP-15942-P) and performed Post-Irradiation Examinations on SVEA-96 Optima2 fuel bundles loaded in European BWRs. PNNL concluded that the Optima2 fuel design will not violate the criterion on fretting wear of assembly components. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, in response to RAI No. 13 and based on PNNL's technical evaluation, the NRC staff finds the fretting wear criterion, methodology, and sample application to Optima2 acceptable.

3.3.8 Corrosion of Assembly Components

The Westinghouse criterion for corrosion of assembly components is that corrosion and crud from assembly components must be accounted for in evaluating functionality, stress, dimensional changes, and thermal hydraulics. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.8 of WCAP-15942-P describes the methodology for minimizing the impact of corrosion and evaluating its effect on assembly components and provides an application for Optima2. In Section 4.1.8 of the TER, PNNL reviewed the methodology and strategies for minimizing corrosion and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the corrosion assessment for the SVEA-96 Optima2 fuel design. No new materials have been introduced for SVEA-96 Optima2, so no new corrosion tests have been performed on any of the assembly components. Past in-reactor experience with the stainless steel and Inconel components has been acceptable. Westinghouse has presented corrosion data for the Zircaloy-2 fuel rod cladding and fuel channels. PNNL concluded that the sample calculation demonstrates that the materials and processes used in SVEA-96 Optima2 assembly components and the oxide database meet the methodology and criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and in PNNL's technical evaluation, the NRC staff finds the corrosion criterion, methodology, and sample application to Optima2 acceptable.

3.3.9 Hydriding of Zircaloy Assembly Components other than Fuel Rods

The Westinghouse criterion for hydriding of Zircaloy assembly components (other than fuel rods) is that hydriding shall not result in unacceptable strength loss. The impact of hydriding on calculated stress in assembly components shall be addressed. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.2.9 of WCAP-15942-P describes the methodology for minimizing the impact of hydriding and evaluating its effect on assembly components and provides an application for Optima2. In Section 4.1.9 of the TER, PNNL reviewed the methodology and strategies for minimizing hydriding. In response to RAI No. 4, regarding the end of life (EOL) design limit, Westinghouse provided strength and elongation data on irradiated specimens at different hydrogen concentrations. Based on the data presented in response to RAI No. 4, PNNL concluded that the methodology and EOL design limit is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the hydriding assessment for the SVEA-96 Optima2 fuel design. Westinghouse has determined the hydrogen pickup fraction based on destructive examination and hydrogen measurements of the fuel channels. Based on the expected corrosion at 55 GWd/MTU, PNNL concluded that sufficient margin exists to the EOL design limit for the fuel channels. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, response to RAI No. 4 and PNNL's technical evaluation, the NRC staff finds the hydriding criterion, methodology, and sample application to Optima2 acceptable.

3.4 Fuel Rod Design Criteria

Westinghouse has identified ten specific criteria to prevent fuel rod damage or failure during normal operation and AOOs. These design criteria, the supporting methodology, and application to the sample Optima2 fuel assembly design are discussed below. As described in Section 3.1 of the SRP, plant-specific changes are required to ensure mechanical compatibility with core components and co-resident fuel. As a result, each licensee must ensure that all of the design criteria are satisfied for their specific Optima2 fuel assembly.

Section 4.3.0 of WCAP-15942-P described the fuel rod power histories used in the fuel rod design analyses. For evaluating steady-state fuel rod performance, six segmented power histories (SPHs), each operating at the thermal mechanical operating limit (TMOL) for one-sixth of the operating life, were modeled. For evaluating AOOs, a database of several thousand power histories was examined to find the power history that provided the maximum value for the parameter of interest (e.g., rod internal pressure). Several power ramps were imposed on this power history at various burnup levels. In Section 4.2 of the TER, PNNL reviewed the power histories used in the various fuel rod design analyses and concluded that these power histories are acceptable. Based on the information provided in WCAP-15942-P, the response to RAIs and PNNL's technical evaluation, the NRC staff finds the power histories used in the fuel rod design analyses acceptable.

3.4.1 Rod Internal Pressure

The Westinghouse criterion for rod internal pressure is not to exceed a value which would cause the outward cladding creep rate to exceed the fuel swelling rate. This is often referred to as the no-clad-lift-off criterion and is consistent with previous rod pressure criteria approved by the NRC. PNNL concluded that this criterion is acceptable for application to SVEA-96 designs.

Section 4.3.1 of WCAP-15942-P describes the methodology for performing the fuel rod internal pressure analysis and provides an application for Optima2. In Section 4.2.1 of the TER, PNNL reviewed the methodology including the calculation of minimum rod internal pressure required for lift-off, the selection of power histories, the selection of the uncertainty analysis parameters, and the calculation of root mean square (RMS) upper bound pressure and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the rod internal pressure evaluation for the SVEA-96 Optima2 fuel design. FRAPCON-3 benchmark cases for Optima2 rod internal pressure were included in the NRC staff's review of WCAP-15836-P (STAV7.2). STAV7.2 provides analytical tools (codes) for evaluating fuel design. WCAP-15942 provides a methodology for using the tools on a given design (OPTIMA2). Benchmark cases for OPTIMA2 were performed in STAV7.2. RAIs were issued with respect to the handling of fuel clad liners and AOOs power histories. As a result of the RAIs, Westinghouse has modified the AOOs power history to include a power pulse at a higher burnup. PNNL concluded that the Optima2 fuel design will not violate the rod internal pressure criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAIs and PNNL's technical evaluation, the NRC staff finds the rod internal pressure criterion, methodology, and sample application to Optima2 acceptable.

3.4.2 Cladding Stresses

The Westinghouse criterion for fuel rod cladding stresses is that failure will not occur and that stresses in the fuel rod are within established limits in accordance with the American Society of Mechanical Engineers Boiler and Pressure Vessel Code. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.2 of WCAP-15942-P describes the methodology for performing the cladding stresses analysis and provides an application for Optima2. In Section 4.2.2 of the TER, PNNL reviewed the methodology and concluded that it is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the cladding stress evaluation for the SVEA-96 Optima2 fuel design and concluded that it will not violate the criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the cladding stresses criterion, methodology, and sample application to Optima2 acceptable.

3.4.3 Cladding Strain

The Westinghouse criterion for fuel rod cladding strain is that the total transient-induced elastic and plastic circumferential strain shall not exceed 1 percent. The 1 percent strain criterion is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.3 of WCAP-15942-P describes the methodology for performing the cladding stresses analysis and provides an application for Optima2. In Section 4.2.3 of the TER, PNNL reviewed the methodology and the selection of models and parameters for the worst case analysis and concluded that it is acceptable for application to SVEA-96 fuel designs. FRAPCON-3 benchmark cases were included in the NRC staff's review of WCAP-15836-P to verify the STAV7.2 predictions of cladding strain.

PNNL reviewed the cladding strain evaluation for the SVEA-96 Optima2 fuel design. In response to RAI No. 21, Westinghouse provided predicted strains at a different power history which included a higher burnup power pulse. The calculated strains remained below the 1 percent criterion. PNNL concluded that the Optima2 fuel design will not violate the 1 percent strain criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 21 and PNNL's technical evaluation, the NRC staff finds the cladding strain criterion, methodology, and sample application to Optima2 acceptable.

3.4.4 Hydriding

The Westinghouse criterion for cladding hydriding is to prevent premature failure due to either internal hydriding or waterside corrosion. The impact of hydrides is accounted for in the stress and strain calculations. The treatment of cladding hydriding is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.4 of WCAP-15942-P describes the methodology to evaluate hydriding and provides an application for Optima2. In Section 4.2.4 of the TER, PNNL reviewed the methodology for controlling hydrogen during manufacturing and minimizing hydrogen pickup during service. In response to RAI No. 4, regarding the basis of the hydrogen design limit, Westinghouse provided strength and elongation data based on testing of irradiated fuel cladding. The database supports the hydrogen design limit requested. PNNL concluded that the hydriding methodology and design limit are acceptable for application to SVEA-96 fuel designs. PNNL reviewed the clad hydriding evaluation for the SVEA-96 Optima2 fuel design. Westinghouse provided operating experience (Figure 4.3.4-1 of WCAP-15942-P) which showed that Optima2's fuel cladding hydrogen concentration at the burnup limit was well below the design limit. PNNL concluded that the Optima2 fuel design will not violate the cladding hydriding criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 4 and PNNL's technical evaluation, the NRC staff finds the clad hydriding criterion, methodology, and sample application to Optima2 acceptable.

3.4.5 Cladding Corrosion

The Westinghouse criterion for cladding corrosion is that excessive corrosion shall not lead to fuel rod failure. In addition, the effect of cladding corrosion shall be included in the thermal and mechanical evaluation of the fuel design. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.5 of WCAP-15942-P describes the methodology for cladding corrosion and provides an application for Optima2. In Section 4.2.5 of the TER, PNNL reviewed the methodology for minimizing the impact of corrosion and evaluating its effect on fuel rod performance. In response to RAI Nos. 9 and 10, regarding future updates to the fitting parameters in the STAV7.2 corrosion and crud models, Westinghouse implemented a process that will develop new coefficients based on measured crud and corrosion values for that given plant, if abnormal crud or corrosion is observed at any given plant (abnormal crud/corrosion layer increases the calculated fuel average temperature by more than 25°C). PNNL concluded that the methodology for minimizing the corrosion and evaluating its impact on rod performance is acceptable for application to SVEA-96 fuel designs. PNNL reviewed the cladding corrosion evaluation for the SVEA-96 Optima2 fuel design. Based upon the LK3 Zircaloy-2 corrosion database provided by Westinghouse, PNNL concluded that the Optima2 fuel design will not violate the corrosion design limit up to the burnup limit requested. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI Nos. 9 and 10 and PNNL's technical evaluation, the NRC staff finds the cladding corrosion criterion, methodology, and sample application to Optima2 acceptable.

3.4.6 Cladding Collapse

The Westinghouse criterion for cladding collapse (elastic and plastic instability) is that collapse will not occur during the life of the fuel rod. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.6 of WCAP-15942-P describes the methodology for cladding collapse and provides an application for Optima2. In Section 4.2.6 of the TER, PNNL reviewed the methodology for selecting limiting input parameters to the COLLAPSE3.3D analysis and performing the limiting cases and concluded that the methodology for confirming that cladding collapse will not occur is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the cladding collapse evaluation for the SVEA-96 Optima2 fuel design. In response to RAI No.6, regarding cladding collapse in the high flux region of the part-length rod plenum, Westinghouse stated that calculated time to collapse exceeds in-reactor service. Westinghouse also stated that cladding collapse has never been observed in Westinghouse BWR fuel designs. PNNL concluded that the Optima2 fuel design will not violate the cladding collapse criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 6 and PNNL's technical evaluation, the NRC staff finds the cladding collapse criterion, methodology, and sample application to Optima2 acceptable.

3.4.7 Cladding Fatigue

The Westinghouse criterion for fatigue damage is that failure shall not occur, taking into account the effects of cladding corrosion. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.7 of WCAP-15942-P describes the methodology for cladding fatigue and provides an application for Optima2. The design fatigue curve includes the more conservative factor of 2.0 on stress amplitude or 20 on the number of cycles. The calculated cumulative usage factor must be less than 1.0 for the design life of the fuel. In Section 4.2.7 of the TER, PNNL reviewed the methodology for selecting limiting input parameters and modeling fatigue damage due to fuel rod power changes and hydraulic forces. PNNL concluded that the methodology is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the cladding fatigue evaluation for the SVEA-96 Optima2 fuel design. Westinghouse provided fatigue evaluations for the standard full length UO_2 and UO_2-Gd_2O_3 fuel rods which demonstrate that the maximum calculated fatigue damage is below the 1.0 usage factor. PNNL concluded that the Optima2 fuel design will not violate the cladding fatigue criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the cladding fatigue criterion, methodology, and sample application to Optima2 acceptable.

3.4.8 Cladding Temperature

The Westinghouse criterion for cladding temperature is that cladding overheating shall not cause fuel rod failure. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.8 of WCAP-15942-P describes the methodology for avoiding cladding overheating. This methodology is based on maintaining adequate margin to boiling transition. The minimum critical power ratio for the Optima2 fuel design was reviewed outside of this topical report.

3.4.9 Fuel Temperature

The Westinghouse criterion for fuel temperature is that the maximum fuel centerline temperature shall remain below the fuel melting temperature. This is consistent with Section 4.2 of the SRP and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.9 of WCAP-15942-P describes the methodology for predicting the maximum fuel temperature during normal operations and AOOs to compare those temperatures to the fuel melting temperatures of the limiting pellets and provides an application for Optima2. FRAPCON-3 benchmark cases were included in the NRC staff's review of WCAP-15836-P to verify the STAV7.2 predictions of fuel temperature. In Section 4.2.9 of the TER, PNNL reviewed the methodology for selecting limiting input parameters (including power histories) and combining model and fabrication uncertainties. PNNL concluded that the methodology is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the fuel temperature evaluation for the SVEA-96 Optima2 fuel design. Westinghouse provided evaluations for the standard UO_2 full-length, 1/3 length, 2/3 length, and UO_2-Gd_2O_3 fuel rods which demonstrate that the maximum calculated fuel temperature for the nominal and RMS upper bound remained below the melting temperatures. PNNL concluded that the Optima2 fuel design will not violate the fuel temperature criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the fuel temperature criterion, methodology, and sample application to Optima2 acceptable.

3.4.10 Fuel Rod Bow

The Westinghouse criterion for fuel rod bowing is that excessive bowing shall be precluded for the fuel assembly life and its impact on fuel rod performance shall be accounted for, if necessary, in the thermal and mechanical evaluation of the fuel rods and assembly. This is consistent with SRP Section 4.2 and, therefore, is acceptable for application to SVEA-96 designs.

Section 4.3.10 of WCAP-15942-P describes the methodology for confirming that excessive bowing shall not occur during the life of the fuel. Excessive bowing is defined as that degree of fuel rod bow which leads to fuel rod damage or significantly impacts the nuclear or thermal-hydraulic performance of the assembly. In Section 4.2.10 of the TER, PNNL reviewed the methodology for minimizing the impact of fuel rod bow and evaluating its effect on fuel rod performance. PNNL concluded that the methodology is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the fuel rod bow evaluation for the SVEA-96 Optima2 fuel design. Based on in-reactor experience, Westinghouse has adopted fuel design features aimed at minimizing the potential for fuel rod bow. In response to RAI No. 19, regarding fuel rod bow experience, Westinghouse provided information on rod bow inspections which demonstrates that excessive rod bow is not likely to occur in SVEA-96 fuel designs up to the requested burnup limit. PNNL concluded that the Optima2 fuel design would not violate the fuel rod bow criterion. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 19 and PNNL's technical evaluation, the NRC staff finds the fuel rod bow criterion, methodology, and sample application to Optima2 acceptable.

3.4.11 Pellet Cladding Interaction

Westinghouse has no criterion for pellet cladding interaction (PCI). SRP Section 4.2 identifies PCI as a failure mechanism, but does not specify criteria to prevent PCI failure other than the 1 percent uniform strain and no fuel melting criteria. Both of these design criteria have been addressed above.

Section 4.3.11 of WCAP-15942-P describes the additional measures employed to avoid PCI-related fuel failure. Westinghouse has introduced a Zirc-tin alloy liner which has proven effective at reducing the potential for PCI damage. In Section 4.2.11 of the TER, PNNL reviewed the PCI methodology and operating restrictions imposed on plants without clad liners. In response to RAI No. 25, regarding the empirical basis for the PCI operating restrictions, Westinghouse provided ramp rate test results and proposed lined and unlined thresholds. PNNL noted that if the threshold for lined fuel is less than the TMOL at any burnup, then the conditioning requirements outlined for unlined fuel must be applied. PNNL concluded that the methodology is acceptable for application to SVEA-96 fuel designs.

PNNL reviewed the PCI evaluation for the SVEA-96 Optima2 fuel design. All SVEA-96 Optima2 fuel will contain LK3 Zircaloy-2 cladding with a Zr-Sn liner. A condition is required to cover any situation where the TMOL exceeds the lined fuel PCI threshold (See Section 4.0, Item #5). PNNL concluded that the Optima2 fuel design would not violate the PCI criteria provided the operating restrictions and conditioning requirements are followed. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 25 and PNNL's technical evaluation, the NRC staff finds the PCI criteria, methodology, and sample application to Optima2 acceptable.

3.5 Steady-State Initialization of Transient and Accident Analyses

The methodology for initializing transients with STAV6.2 was provided in an RAI response to CENPD-287-P-A. Although essentially the same, this methodology for STAV7.2 was incorporated into the body of WCAP-15942-P. The STAV7.2 code provides initial steady-state gap conductance, gap size, gas composition, and plenum volumes to the loss-of-coolant accident (LOCA) analysis. The STAV7.2 code is also used to initialize the gap heat transfer coefficient for fast transients, control rod drop, and stability analyses.

3.5.1 Calculation of Gap Heat Transfer Coefficients

Section 4.4.1 of WCAP-15942-P describes the methodology for calculating nominal, upper bound, and lower bound gap heat transfer coefficients. In Section 4.3.1 of the TER, PNNL reviewed the selection of parameters and the treatment of uncertainties in the STAV7.2 gap heat transfer calculation. In response to RAI No. 8, regarding the use of these methods on non-Westinghouse co-resident fuel, Westinghouse stated that the use of the methods described in WCAP-15942-P will be limited only to gap heat transfer coefficient. Further, to perform these calculations on non-Westinghouse fuel, the utilities would need to provide sufficient information on the design and operating characteristics. If sufficient information was not available, uncertainties and biases would be increased for the co-resident fuel, such that the gap heat transfer coefficient would be bounded conservatively with 95 percent probability. PNNL concluded that the methodology is acceptable for the application to SVEA-96 fuel designs.

In response to RAI No. 23, regarding an example gap conductance calculation, Westinghouse provided results for a full-length UO_2 fuel rod using the maximum centerline temperature power history. The nominal, maximum, and minimum gap heat coefficients are plotted in Figure 23-1 of the response to the RAI. PNNL reviewed the sample calculation and concluded that it is acceptable. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI Nos. 8 and 23 and PNNL's technical evaluation, the NRC staff finds the methodology for calculating gap heat transfer coefficients acceptable. This methodology is approved for the calculation of gap heat transfer coefficients for both Westinghouse SVEA fuel designs and non-Westinghouse fuel designs (See Section 4.0, Item #3b).

3.5.2 Fast Transient Analyses

Section 4.4.2 of WCAP-15942-P describes the methodology for selecting the gap heat transfer coefficients for the average and hot channel calculations. In Section 4.3.2 of the TER, PNNL reviewed the methodology for initialization of the fast transient analysis using the STAV7.2 gap heat transfer coefficients and the treatment of uncertainties and concluded it was acceptable. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the methodology for initializing fast transient analyses acceptable.

3.5.3 Control Rod Drop Analysis (CRDA)

Section 4.4.3 of WCAP-15942-P describes the methodology for selecting the gap heat transfer coefficients for the CRDA. In Section 4.3.3 of the TER, PNNL reviewed the methodology for initialization of the CRDA using the STAV7.2 gap heat transfer coefficients and the treatment of uncertainties and concluded it is acceptable. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the methodology for initializing CRDA acceptable.

3.5.4 LOCA Analysis

Section 4.4.4 of WCAP-15942-P describes the use of the STAV7.2 and CHACHA-3 codes in the LOCA analysis and the treatment of uncertainties. In Section 4.3.4 of the TER, PNNL reviewed this methodology along with a sample calculation for the Optima2 fuel design. FRAPCON-3 benchmark cases were included in the NRC staff's review of WCAP-15836-P to verify the STAV7.2 predictions of fuel stored energy. In response to RAI No. 5, regarding the LOCA power history used in WCAP-15942-P, Westinghouse acknowledged that it would be difficult to confirm that the assumed power history (which was below the TMOL) remains limiting during the operating cycle. Westinghouse revised the methods to use the six SPHs to bound all operation defined by the TMOL. PNNL concluded that the LOCA initialization methods are acceptable. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P, the response to RAI No. 5 and PNNL's technical evaluation, the NRC staff finds the methodology for initializing LOCA analysis acceptable.

3.5.5 Stability Analysis

Section 4.4.5 of WCAP-15942-P describes the methodology for selecting the gap heat transfer coefficients for the stability analysis. In Section 4.3.5 of the attached TER, PNNL reviewed the methodology for initialization of the stability analysis using the STAV7.2 gap heat transfer coefficients and the treatment of uncertainties and concluded it is acceptable. PNNL noted that plant-specific analysis must be performed by each licensee. Based on the information presented in WCAP-15942-P and PNNL's technical evaluation, the NRC staff finds the methodology for initializing the stability analysis acceptable.

3.5.6 Dose Calculations

Section 4.4.6 of WCAP-15942-P states that the fission product inventory predicted by STAV7.2 is not utilized in dose calculations. The dose calculations are performed in accordance with current NRC regulations and guidance on radiological source terms. Since the STAV7.2 methods are not employed, the assumptions used in the dose calculations are outside the scope of this review.

4.0 LIMITATIONS AND CONDITIONS

Licensees referencing WCAP-15942-P must comply with the following limitations and conditions:

1. Following the fuel assembly and fuel rod mechanical design methodology described in WCAP-15942, as amended by RAI responses, the licensee must ensure that all of the design criteria (described in Sections 3.2, 3.3, and 3.4 of this safety evaluation) are satisfied on a cycle-specific basis.

2. The reference fuel assembly design, SVEA-96 Optima2, is approved up to a peak rod average burnup of 62 GWd/MTU.

    a. In addition to referencing this report in their license amendment request submittal for implementing SVEA-96 Optima2, licensees must include a description of the plant-specific changes which are being made to ensure mechanical compatibility with core components and co-resident fuel. Further, the licensee must demonstrate that these changes are within the envelope of approved plant-specific changes discussed in Section 3.1.

    b. Modifications to the fuel assembly design, beyond the mechanical compatibility changes identified in Section 3.1, will invalidate the staff's approval of the SVEA-96 Optima2 reference fuel design. The provisions described in Section 3.1.4 of WCAP-15942-P, "New Design Features," are not approved.

3. The fuel mechanical design methodology and design criteria are approved up to a peak rod average burnup of 62 GWd/MTU.

    a. These methods are approved for application to currently approved Westinghouse SVEA fuel assembly designs.

   b. These methods are also approved for the calculation of gap heat transfer coefficients (as described in Section 4.4 and the response to RAI No. 23) for mixed cores containing non-Westinghouse fuel designs.

4. During initial implementation, licensees must submit to the NRC an evaluation of control blade interference taking into account manufacturing tolerance, channel bulge, and channel bow over the life of the fuel assemblies (similar to RAI No. 15 response). As part of this evaluation, the licensee must demonstrate the following:

   a. The calculated maximum channel-to-control rod interference (blade and roller/pad) must be less than that determined for the reference plant defined in the response to RAI No. 15.

   b. Westinghouse's channel bow database remains valid. This demonstration must consider the materials and manufacturing process employed in the fabrication of the SVEA channels.

   c. The control rod force-time [$((P_{accumulator} \times A_{annulus})\ t_{CR\text{-}73\%}) / M_{CR}$] for the target plant must be calculated using the methodology outlined in the response to RAI No. 15 and the value of the control rod force-time must be greater than or equal to the force-time parameter for the reference plant.

   d. The SVEA channel experience is applicable for the specific application and continues to be bounded by the database presented in the response to RAI No. 15. This condition is satisfied by assessing the trend in control rod insertion time (e.g., the number of "slow" control rods) in U.S. plants which have implemented SVEA fuel channels since the time of issuance of this safety evaluation. This demonstration should identify the number of "slow" control rods as well as the historical significance of these indications. Updates to the database reflecting new channel bow data measurements may be used to address increasing trends in the numbers of slow rods. The updated database will be used as the bases to evaluate control blade interference.

5. The lined SVEA fuel PCI threshold on a linear heat generation rate (LHGR) must be shown to exceed the TMOL LHGR over the entire burnup range, otherwise fuel PCI conditioning guidelines applicable to non-lined fuel must be applied beginning at LHGRs in excess of the lined fuel PCI threshold.

5.0 CONCLUSION

Based on its review of this TR and technical support provided by PNNL, the NRC staff finds Westinghouse’s fuel mechanical design methodology acceptable. Licensees referencing this TR will need to comply with the conditions listed in Section 4.0 of this SE.

The fuel design criteria presented in WCAP-15942-P, as amended by the RAI responses, satisfy all SRP Section 4.2 fuel assembly criteria and are acceptable for application to SVEA-96 designs.

The fuel mechanical design methodology presented in WCAP-15942-P, as amended by the RAI responses, is acceptable for application to SVEA-96 fuel designs up to a peak rod average burnup of 62 GWd/MTU.

Section 3.1, of WCAP-15942-P, defines the SVEA-96 Optima2 fuel assembly design product description, including the allowed mechanical compatibility changes. The sample application reviewed by the NRC staff demonstrates that this fuel assembly design meets all of the requirements. Plant-specific and cycle-specific evaluations are required to ensure that the Optima2 assembly design continues to satisfy all of the design criteria.

The NRC staff's review did not include the performance of the SVEA-96 Optima2 fuel design under Seismic/LOCA and transportation loads. In addition, the NRC staff's review did not include the provisions described in Section 3.1.4 of WCAP-15942-P, "New Design Features."

The NRC staff's approval of WCAP-15942-P establishes the licensing basis of Westinghouse's BWR fuel design criteria and fuel mechanical design methodology and of the SVEA-96 Optima2 reference fuel design. Licensees wishing to implement this fuel design criteria and methodology, which supports a peak rod average burnup of 62 GWd/MTU, are required to submit a license amendment request, where applicable, updating their core operating limit report list of methodologies. Similarly, the "A" version of WCAP-15942-P may be referenced by licensees in license amendment requests for batch implementation of SVEA-96 Optima2.

6.0 REFERENCES

1. Letter from J. A. Gresham (W) to U.S. Nuclear Regulatory Commission, "Responses to NRC Request for Additional Information on WCAP-15942-P, 'Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287,' " LTR-NRC-05-35, June 30, 2005.

2. NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, Section 4.2, "Fuel System Design," Draft Revision 3, April 1996.

Principal Contributor: Paul Clifford

Date:

Attachment: Resolution of Westinghouse Comments

RESOLUTION OF WESTINGHOUSE COMMENTS

ON DRAFT SAFETY EVALUATION FOR TOPICAL REPORT WCAP-15942-P, "FUEL

ASSEMBLY MECHANICAL DESIGN METHODOLOGY FOR BOILING WATER REACTORS -

SUPPLEMENT 1 TO CENP-287," REVISION 0

By letter dated December 7, 2005, Westinghouse provided comments on the draft safety evaluation (SE) for WCAP-15942-P, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," Revision 0. Westinghouse stated that the name of a particular plant identified in the draft SE and related figure on Page 6 is proprietary. The NRC staff agrees with the Westinghouse comments and the proprietary information has been marked as such in the proprietary versions of the final SE, and omitted from the non-proprietary versions of the final SE.

Attachment