Responses to NRC Request for Additional Information for the Westinghouse Electric Company (Westinghouse) Topical Report (TR) WCAP-17769-P/WCAP-17769-NP, Revision 0, "Reference Fuel Design SVEA-96 Optima3"

August 2016

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

RAI-01

Given that Page 2-3 states that the Optima3 design could lead to increased fuel loading, and that the longer part-length rods could similarly increase loading, justify the statement that the Optima2 and Optima3 designs are neutronically the same (Page 4-73).

Response to RAI-01

It should be noted that the example in Page 4-73 is only illustrative, whereas the safety analyses are always performed for plant- and cycle-specific power histories, with the explicit modeling of the actual fuel dimensions and material properties. For the sole purpose of illustrating the methodology, the strong similarities between SVEA-96 Optima2 and Optima3, from the physics point of view, were considered sufficient to motivate the use of SVEA-96 Optima2-based power histories.

To avoid any confusion, the second sentence of the first paragraph on Page 4-73 of the licensing topical report will be modified as follows. The first sentence of that paragraph is included here for context.

Current Rev. 0:

[

]a,c

Revised:

[

]a,c

RAI-02

Section 3.2.5 mentions using collapse load analysis criteria as an alternative to the design limits for stress determined by the American Society of Mechanical Engineers (ASME) boiling and pressure vessel committee (BPVC), yet the discussion also says it is based on the ASME BPVC. Please clarify this contradiction. Assuming both methods are part of the ASME BPVC, there should be some discussion regarding the criteria used to determine the appropriate method. Describe how the collapse load analysis will be selected as opposed to the nominal ASME BPVC approach to establish design limits for stress during normal operation and anticipated operational occurrences.

Response to RAI-02

The proposed methodology is based on ASME Boiler and Pressure Vessel Code 2010, Section III Subsection NB. The Westinghouse collapse load analysis is the Plastic Analysis defined in ASME BPVC 2010 NB-3228.3. The Westinghouse collapse load analysis is performed using nonlinear finite element simulations based on large deformation theory in order to capture cladding ovality effects on collapse.

[

]a,c

[

(Description of the Westinghouse collapse load analysis method)

][a,c]

RAI-03

It is unclear whether or not predictions based on data collected from tie plates and spacers irradiated to an [ ]^{a,c} respectively, is adequate justification for reaching [ ]^{a,c} Please justify the use of data collected at lower assembly-average (or rod-average) burnup to reach [ ]^{a,c} respectively. Please state if there is intent to re-use irradiated fuel channels in new fuel assemblies.

Response to RAI-03

The general approach for SVEA fuel development, as can be seen in WCAP-17769 Section 2 and Section 7, is evolution rather than revolution. In addition to prototype testing, new fuel features are, to the largest extent possible, based on previous successful operating experience of similar fuel features, followed by verification via lead test programs. This approach is also valid for SVEA-96 Optima3 fuel.

SVEA-96 Optima3 fuel was inspected in November 2014 at an assembly average burnup of [ ]^{a,c}. Two fuel assemblies were inspected, including bottom tie plates and detailed inspection of spacers and also including extraction and reinsertion of fuel rods. There were no findings and both assemblies were approved for further irradiation. The extrapolation of SVEA-96 Optima3 inspection results from an assembly average burnup of [ ]^{a,c} to an assembly average burnup of [ ]^{a,c} is thus small and successful SVEA-96 Optima3 operational experience with assembly average burnup reaching above [ ]^{a,c} already exists. For comparison the maximum rod exposure for SVEA-96 Optima2 has been determined to be [ ]^{a,c} using approved methods from WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," March 2006. The SVEA-96 Optima2 and SVEA-96 Optima3 burnup limits are thus consistent and appropriate.

Furthermore, both bottom tie plates and spacers are exposed to very moderate loads during normal operation and have in tests shown large margins to loads at special events. Bottom tie plates and spacers with the same materials, similar manufacturing techniques and similar operational conditions and functional requirements have also successfully been used in all SVEA fuels, including [ ]^{a,c}

Therefore, the inspection results and operational experience collected for SVEA-96 Optima3 bottom tie plates and spacers, supported by extensive and successful experience of bottom tie plates and spacers in all other SVEA fuels, with the same materials, similar manufacturing techniques and similar operational conditions and functional requirements for these components, is judged to be adequate justification for reaching [ ]^{a,c} However, the SVEA-96 Optima3 inspection program continues and detailed inspections at higher burnup will follow.

No SVEA fuel components, neither channel nor any other fuel component, is re-used in new fuel assemblies except in single cases where test assemblies, under controlled conditions, may be equipped with re-used components such as channels or fuel rods to gain further experience at higher burnup. In these single cases each component to be re-used is carefully characterized before insertion into a new (lower burnt) assembly and the continued operation of the test assembly is followed in an inspection program.

RAI-04

Are there weld qualifications that should be referenced? Aside from irradiation experience, is there any documentation that can be cited to indicate that the welds have undergone a rigorous weld qualification that ensures the laser beam welds are as robust as the electron beam welds?

Response to RAI-04

The SVEA-96 Optima3 spacer is built from spacer cells and frames. The cells are fabricated from Nickel Base Alloy strip, punched, stamped and coiled to form octagonal cells. All manufacturing steps as from coiling of cells to welded spacer are made in a fully automated manufacturing line at the Westinghouse Electric Sweden (WSE) Nuclear Fuel Facility.

Welding processes at WSE are performed according to internal instructions and qualified according to [

]a,c

Personnel for welding are qualified according to the ISO standard, SS-EN ISO 14732, "Welding personnel – Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials."

There have never been any fuel failures in SVEA fuel related to spacer malfunction, [ ]a,c SVEA-96 Optima3 type spacers were introduced in 2004, and the manufacturing as well as operating experience is now significant with more than [ ]a,c SVEA-96 Optima3 spacers delivered, corresponding to about [ ]a,c

The welding qualification documents are considered internal documentation and are typically not referenced in our fuel licensing topical reports. However these documents can be made available for audit by NRC personnel.

RAI-05

The TR does not specifically state which of the uncertainties will be used for rod internal pressure. On TR Page 4-79 it is stated that the following uncertainties are typically considered for rod internal pressure. How does the methodology decide which uncertainties are actually considered? On Page 4-81 sample calculation of the critical lift-off pressure concludes that it is [ ]^{a,c} Where does the [ ]^{a,c} come from since evaluation seems to be done for worst case models (lower bound swelling and upper bound creep rate, max clad inner diameter, min clad outer diameter)?

Response to RAI-05

Within the SVEA-96 Optima2 Topical Report (WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," March 2006) supporting calculations a study was performed to identify the parameters and uncertainty directions to be considered. This has been carried forward for the SVEA-96 Optima3 supporting calculations as the fuel rod design does not have significant differences. Consequently the methodology for SVEA-96 Optima3 is consistent with that of SVEA-96 Optima2.

The uncertainty stated for the critical lift-off pressure represents the range of lift-off pressures achieved for different LHGRs (see Figure 4.3.2-2 in the topical report). In the sample application the lower bound of this range is chosen as the critical lift-off pressure to be compared against.

To provide a clear statement on the uncertainties considered in the rod internal pressure evaluation, the topical report will be modified. The last sentence of the fourth paragraph in Section 4.3.2, Page 4-79, will be modified as follows. The complete paragraph is included here for context.

Current Rev. 0:

The dependence of the maximum fuel rod internal pressure on uncertainties in parameters to which the fuel rod pressure is sensitive is established, and an EOL value encompassing the significant uncertainties is established for comparison with the critical pressure required for fuel rod lift-off established in Step 1. The most limiting value of any parameter with a significant impact on fuel rod pressure, which is not included in the uncertainty evaluation, is utilized in the nominal calculation. Uncertainties in the following parameters are typically considered:

Revised:

The dependence of the maximum fuel rod internal pressure on uncertainties in parameters to which the fuel rod pressure is sensitive is established, and an EOL value encompassing the significant uncertainties is established for comparison with the critical pressure required for fuel rod lift-off established in Step 1. The most limiting value of any parameter with a significant impact on fuel rod pressure, which is not included in the uncertainty evaluation, is utilized in the nominal calculation. [
]^{a,c}

RAI-06

The use of ANSYS was approved for determining assembly stress in Reference 2 of the submittal, but not for determining cladding stress. The description of the ANSYS model is very limited. With regard to Table 4.3.3-1 on Page 4-89, please explain what is meant by items in the first column. Also, how is maximum allowed differential pressure calculated?

Response to RAI-06

The unmarked column in Table 4.3.3-1 is the fuel rod power during the AOO overpressure transient. Included in the table are two examples of fuel rod power [ ]^{a,c} for limiting AOO overpressure transients. As can be seen, the margin to Maximum Allowed Differential Pressure is [ ]^{a,c} It can then be concluded that the margin to the stress limits for the SVEA-96 Optima3 will be acceptable for any credible BWR application. For example [ ]^{a,c}

Maximum allowed differential pressure is calculated by using Westinghouse collapse load analysis. [ ]^{a,c}

[

(Description of calculation of allowed differential pressure using collapse load analysis)

]a,c

To avoid confusion, the licensing topical report will be modified as follows:

Current Rev. 0:

Table 4.3.3-1 Maximum Differential Pressure Over Cladding

	Coolant Pressure	Cladding Temperature	Maximum Allowed Differential Pressure	Calculated Differential Pressure Over Cladding

a,c

Since the maximum allowed differential pressure exceeds the calculated differential pressure over the cladding [ ]a,c it is concluded that the margin to the stress limits for the SVEA-96 Optima3 will be acceptable for any credible BWR application.

Revised:

Table 4.3.3-1 Maximum Differential Pressure Over Cladding

Coolant Pressure	Cladding Temperature	Example Power[1)]	Maximum Allowed Differential Pressure	Calculated Differential Pressure Over Cladding

a,c

[

]a,c

Since the maximum allowed differential pressure exceeds the calculated differential pressure over the cladding [ ]a,c, it is concluded that the margin to the stress limits for the SVEA-96 Optima3 will be acceptable for any credible BWR application. For example [

]a,c

RAI-07

On Page 4-90 the sample application for cladding strain does not show in the table how cladding corrosion is used (e.g., max, min, model parameter maximized). [ ]^{a,c} Please provide details of how cladding corrosion is used in the uncertainty analysis for cladding strain.

Response to RAI-07

The cladding corrosion is internally calculated by the STAV code and the effect of [ ]^{a,c} accounted for within the STAV calculation of the strain. [

]^{a,c}

RAI-08

Although the methodology is unchanged, NRC staff recommends that, moving forward, it may be better to have an approved hydrogen pickup model in STAV7.2 rather than no approved model and a methodology that relies on data. An approved model is also recommended to support reactivity insertion accident and loss-of-coolant-accident criteria. [

]a,c

Response to RAI-08

Westinghouse's intention is to [
]e

The STAV7.2 hydrogen model has been accepted by the NRC, in connection with the review of Appendix A to WCAP-16747-P-A, "POLCA-T: System Analysis with Three-Dimensional Core Model," for the purpose of determining the cladding hydrogen content at the onset of postulated transients such as a BWR control rod drop accident. However, the model is an upper-bound model that was developed to predict the maximum hydrogen uptake at licensed discharge burnups.

RAI-09

On TR Page 4-108 the cladding temperature methodology does not specify that [ ]^{a,c} be accounted. Please provide justification for not considering [ ]^{a,c} in the cladding temperature analysis.

Response to RAI-09

Cladding failure due to overheating is not a credible mechanism during normal operation or anticipated operational occurrences (AOOs). Cladding temperature calculations are therefore not performed for normal operation and AOOs and consequently, [ ]^{a,c} Specific cladding temperature calculations are performed for initiating events of lower frequency of occurrence. Methods and methodologies for analysis of these accidents are described in other Licensing Topical Reports and are outside the scope of WCAP-17769-P.

As stated in Section 4.3.9, the Westinghouse methodology for evaluating the potential for cladding failure due to overheating follows the traditional industry practice of assuming that failures will not occur if adequate margin to boiling transition (the Safety Limit Minimum Critical Power Ratio, SLMCPR) is maintained. The plant Operating Limit Minimum Critical Power Ratio (OLMCPR) is established for this purpose considering all possible plant transients classified as AOOs. The OLMCPR is determined such that MCPR reduction due to anticipated operational transients does not result in a MCPR below the SLMCPR. The criterion is, however, considered to be overly conservative regarding cladding overheating damage.

RAI-10

It is unclear if Westinghouse will use the boiling water reactor (BWR) pellet-clad mechanical interaction (PCMI) fuel cladding failure criteria from Standard Reactor Plan 4.2 for control rod drop accident (CRDA). Also, it is not clear if dose will be calculated for CRDA with failed fuel. Such calculations should be checked against Regulatory Guide (RG) 1.3 and RG 1.25. Will the BWR PCMI fuel cladding failure criteria be applied to CRDA? Will a dose be calculated for a CRDA assuming failed fuel and, if so, how will the dose be calculated?

Response to RAI-10

The Control Rod Drop Accident (CRDA) methodology and acceptance criteria are addressed outside the scope of WCAP-17769-P. The CRDA is included in Topical Reports CENPD-284-P-A, "Control Rod Accident Analysis Methodology for Boiling Water Reactors: Summary and Qualification," for the RAMONA code and Appendix A to WCAP-16747-P-A, "POLCA-T: System Analysis with Three-Dimensional Core Model," for the POLCA-T code. New fuel reload applications will be analyzed with POLCA-T.

In WCAP-16747-P-A (POLCA-T), Westinghouse has committed to the following criteria. The same criteria would be applied if the RAMONA methodology is used.

- Until final acceptance criteria are published by the NRC, POLCA-T methodology will determine the extent of fuel damage using the interim acceptance criteria in SRP 4.2, Revision 3 Appendix B for new reactor applications.
- Once the final acceptance criteria are published by the NRC, the POLCA-T methodology will adopt these criteria for all CRDA analysis.

It should be noted that WCAP-17769-P, "Reference Fuel Design SVEA-96 Optima3," provides only the description of the fuel design and the determination of the Specified Acceptable Fuel Design Limits for the fuel design in question as specified in the Chapter 4 Standard Review Plans. The methodology, including the acceptance criteria, for the safety analyses described in the SRP Chapter 15 are described in various other Licensing Topical Reports. Also, the evaluation of radiological consequences based on the fuel damage determined using either POLCA-T or RAMONA is beyond the scope of this LTR.

RAI-11

A cladding strain sample application previously applied to Optima2 for [ ]^{a,c} was repeated for Optima3 for only [ ]^{a,c} Show the sensitivity to hold time or justify why [ ]^{a,c} is not realistic.

Response to RAI-11

In the SVEA-96 Optima2 Topical Report (WCAP-15942-P-A, "Fuel Assembly Mechanical Design Methodology for Boiling Water Reactors - Supplement 1 to CENP-287," March 2006) supporting calculations, Westinghouse performed the Rod Internal Pressure for Anticipated Operational Occurrences (AOO) calculations using a hold time of [ ]^{a,c} The cladding strain AOO calculations were performed using a conservative hold time of [ ]^{a,c} This is consistent with the treatment in the SVEA-96 Optima3 calculations.

To correct this typo in Section 4.3.2 of the licensing topical report, the last sentence in the second paragraph under the subheading "Maximum Internal Pressure," Page 4-82, will be modified as follows:

Current Rev. 0:

[ ]^{a,c}

Revised:

[ ]^{a,c}

RAI-12

Are rod burnup limits the same for full and part-length fuel rods? What is the peak pellet burnup limit?

Response to RAI-12

The supporting analyses presented in the topical report show that both the full and part-length fuel rods satisfy the criteria up to the rod burnup limit of [ ][a,c] An explicit peak pellet burnup has not been presented in the topical report, although the analyses presented cover the expected maximum achievable pellet burnups up to a rod burnup limit of [ ][a,c]